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SPEED OF MINING CAGES.

IN the course of a discussion between miners, on the speed with which a miners' cage can be hoisted and lowered in a shaft, one of them said that the fastest time ever made in lowering was in the Union shaft. A cage with men was dropped from the surface to the 2,900 level in one minute and 12 seconds. This was at the speed of a little more than 40 feet in a second, and slightly less than 30 miles an hour. On another occasion, when a shaft was flooded through the breaking of a pump, 63 tanks of water were raised to the surface from the 1,300 level in the space of one hour. During this time it was necessary for the cable in ascending and descending to travel 2,600 feet in less than one minute, making a total of nearly 32 miles traveled in the hour.—*Virginia Chronicle.*

EXPRESS ENGINE, GREAT WESTERN RAILWAY.

MR. WILLIAM DEAN, locomotive superintendent of the Great Western Railway, has built an express engine with the eccentrics outside, which we illustrate. Our views give an external elevation of the whole engine and a detailed view of the leading end. The arrangement is intended to get rid of the excessive cramping up of the valve gear necessary when large cylinders have the valve chests placed between them. It will be seen that in this case the valves lie on top of the cylinders, and are driven by rocking shafts, the eccentrics being, as we have said, placed outside the wheels instead of inside. This gives more room for bearings, permits a longer crank pin to be used, and gives several other advantages, against which is only to be set the use of rocking shafts, concerning which little can really be urged. The engine is giving, we understand, complete satisfaction. Mr. Dean, to whom we are indebted for the drawings we reproduce, has courteously added the following particulars as to the dimensions of the engine:

GREAT WESTERN RAILWAY ENGINE NO. 9.

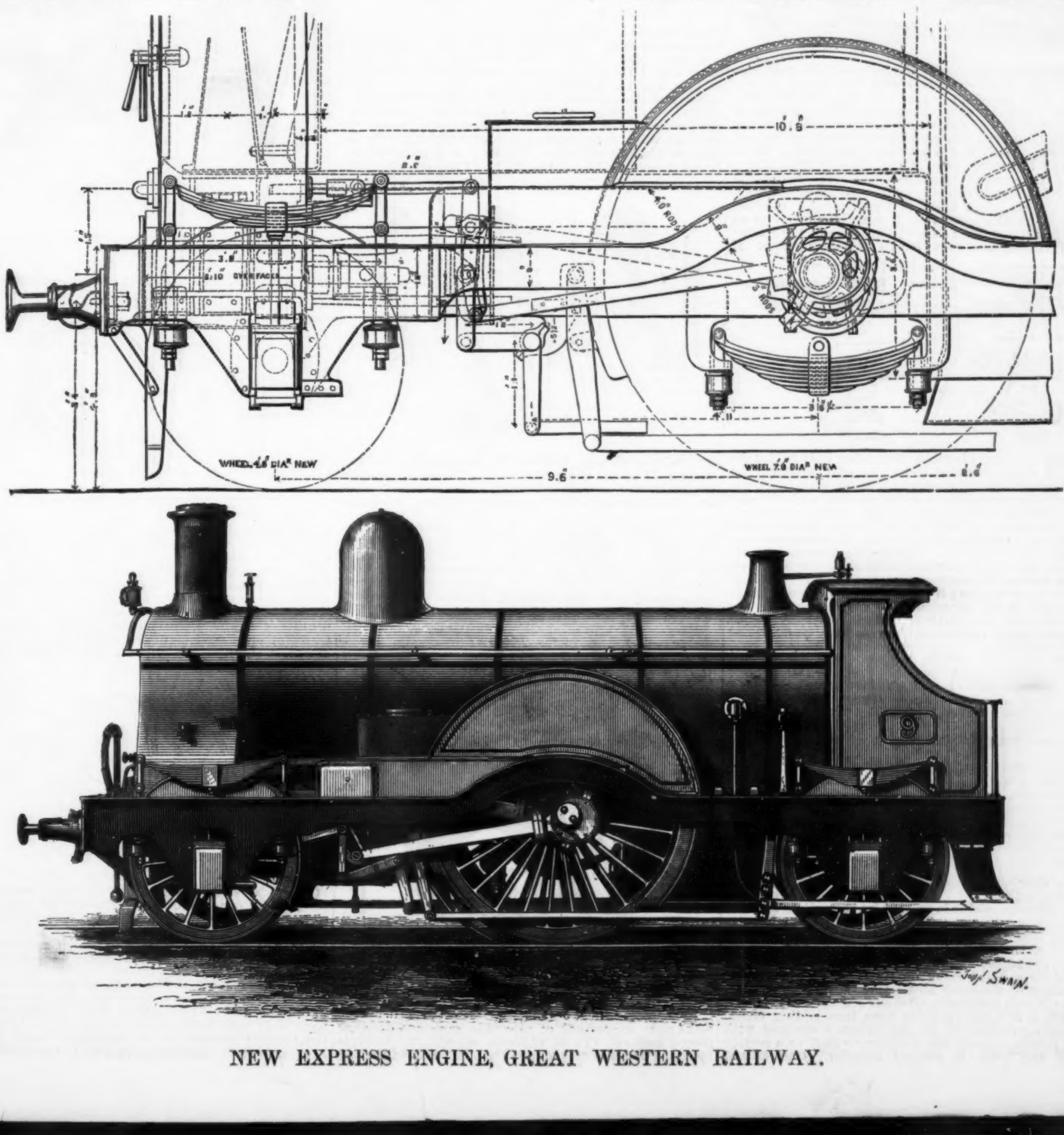
Cylinders, diameter.......	1 ft. 6 in., stroke, 2 ft. 2 in.
Boiler barrel	10 ft. 8 in. long.
" "	4 ft. 3 in. outside diameter.
Outside fire-box...........	6 ft. 2 in. by 4 ft.
Inside fire-box. 5 ft. $5\frac{1}{8}$ in. by	3 ft. 6 in. by 6 ft. $2\frac{1}{8}$ in. high.
Tubes, 241	$1\frac{5}{8}$ in. by 10 ft. $11\frac{1}{4}$ in. long.
Wheels, leading...........	4 ft. 6 in. diameter.
Wheels, driving...........	7 ft. 8 in. diameter.
Wheels, trailing...........	4 ft. 6 in. diameter.
Wheel base, L. to D.......	9 ft. 6 in.
Wheel base, D. to T	8 ft. 6 in.
Total.................	18 ft. 0 in.
Heating surface, tubes ...	1120 square feet.
" " fire-box..	130 square feet.
Total.................	1250 square feet.
Working pressure...	150 lb. per square inch.
Fire-grate area............	19·23 square feet.

—*The Engineer.*

PULVERIZING MACHINES.

PROF. VON HERMANN TISCHER, of the Technical High School, Hanover, recently published—*Zeitschrift des Vereins Deutscher Ingenieure*—some interesting and, in several respects, suggestive considerations of the action of pulverizing machines in general, and on stone breaking machines in particular. From his writings we extract much of what follows, and believe it will be found interesting to many of our readers.

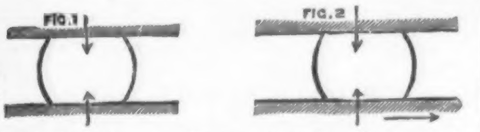
Before discussing the different machines themselves, it will be better to call attention to the characteristics of pulverizing, and to introduce a few practical examples. Pulverization is seldom pushed to extremes; usually a certain definite size of the reduced particles is desired, and sometimes it is only for tearing apart substances which exist in masses hanging together. This is, perhaps, better named disintegration. The nature of the substance, its tenacity, texture, etc., render it necessary to use different treatment; for example, the material used for making paper requires to be torn to pieces so as to produce a fibrous pulp, others, such as ores, to be reduced to fine granular powders. In the former case, the disintegration must take place in a longitudinal direction, or along the lines where the masses or bundles of fibers are weakest. In some substances a step by step or gradual reduction will produce a fairly regular result. Even from an unhomogeneous body, the more gentle action of gradual reduction, combined with the separation of the suffi-



NEW EXPRESS ENGINE, GREAT WESTERN RAILWAY.

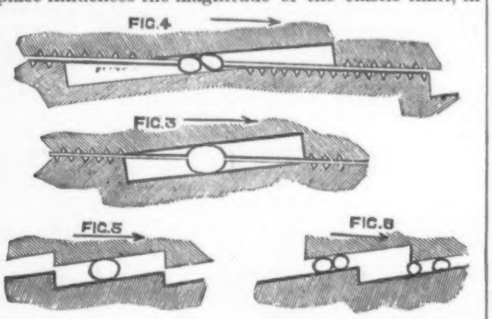
ciently reduced particles as soon as they are formed, gives a better chance to the harder particles of being subjected to more disintegrating action than the softer particles.

A close examination of the action of pulverization will be useful. Before pulverization of any body can take place, the same must be strained to the limit of elasticity. The work done in pulverization may be divided into two parts—one, A_1, corresponding to the elastic limit, and the other, A_2, that force over and above A_1 which is necessary to bring about the disintegration. It is not easy to separate the two forces clearly in either very brittle or very elastic bodies, but they may be easier separated in bodies which are suffi-



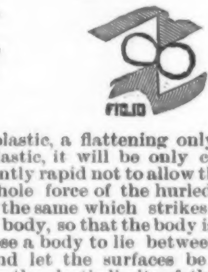
ciently tenacious to allow of "flow" of the particles of which they consist. Taking two substances, one—glass—whose elastic limit is small, and, therefore, is considered a brittle substance, and another with a wide elastic limit—India rubber—it will be easily seen that loss of power expended in disintegrating a mixture of particles of the two substances would occur, because the work that would break up the particles of glass would simply be lost on the India rubber; therefore, for economical pulverizing, it is essential to deliver the material to the pulverizing machine in as homogeneous condition as possible.

The speed with which the pulverizing action takes place influences the magnitude of the elastic limit, in



that the internal friction of the body—of the particles forming the body—increases with the speed of the action. The speed also influences the "flow" of the particles. A quick action causes this disintegration to happen sooner than a slow action, so that for reducing somewhat tough or pliable bodies a quick action is of advantage. With few exceptions, the action takes place only in a small part of the outer surface of the bodies; the pressure thus exerted, on account of the inertia of the body, can only spread gradually throughout the mass. If a body be hurled against another body at so great a speed that it may be considered as rigid, then the moving force—(?) kinetic—of the hurled body furnishes the force for its own destruction. If

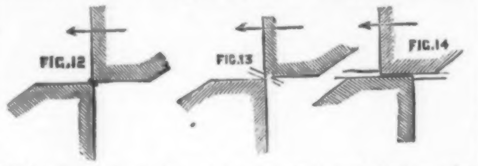
the body be very plastic, a flattening only will take place; if slightly plastic, it will be only cracked, the action being sufficiently rapid not to allow the particles to flow. But the whole force of the hurled body only acts on that part of the same which strikes on the surface of the resisting body, so that the body is unequally acted upon. Suppose a body to lie between two rigid surfaces—Fig. 1—and let the surfaces be forced together at first within the elastic limits of the body; on further forcing the surfaces together, the body will continue to alter in form; if plastic, it will flatten out into a cake, or, if the movement of the surfaces be too quick to allow the particles to flow, the body will be split into many fragments. Bodies may be flattened



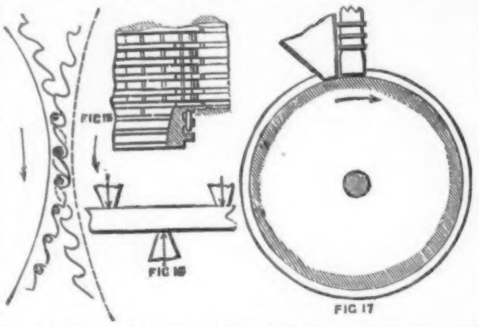
out by slow action that would be split into fragments by quick action.

The pressure which is exerted by the acting surfaces on the body between them is not distributed quite equally over the same. On one side there is the internal friction of the smallest particles of the body in opposition to the regular transmission of the force; the friction of the crushed body on the surfaces hinders the movement of the same along these surfaces. According to Kick's researches (*Dingler's Poly. Journ.*, 1877, vol. 224, p. 465), the particles form into sliding cones, supporting themselves on the pressure surfaces with their points toward one another, so that to a certain extent the body is wedged asunder. One cannot reckon on a perfectly uniform result with pressure only between surfaces as just described. Unhomogeneous bodies split along the weakest place, perhaps in a plane of crystallization. As examples of pulverizing by simple pressure, stamping mill and crushing rolls run at equal periphery speeds may be cited.

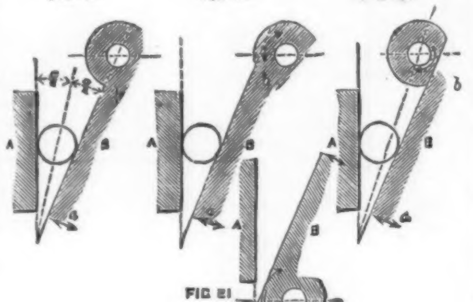
If the surfaces are pushed while they are approaching each other—Fig. 2—and if the friction of the body on them be sufficient, it will roll between them, and will soon be torn asunder in a direction parallel to the direction of the pushing action. Sometimes during what is called grinding action an unobserved tearing action takes place. Supposed to be acted on by two opposing forces on opposite sides of



the body while it is not in a condition to follow this pair of forces by rolling, part of the body will follow one force and part the other force, and a separation will take place along the plane of the weakest place, supposing that the two acting forces are sensibly parallel to each other. This fact is made use of in preparing paper pulp and in the reduction of corn. Such action takes place with rollers running at different periphery speeds and with millstones. The action



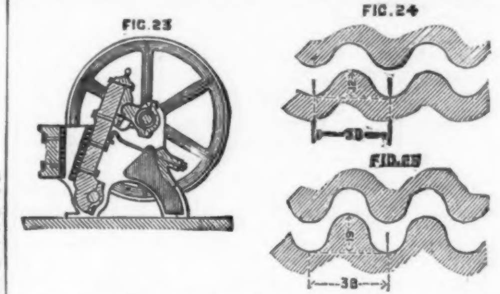
of millstones is clearly shown by the cross sections—at right angles to the furrows—in Figs. 3 and 4, and does not need description. The shearing action, with sharp-edged furrows running in an opposite direction to Figs. 3 and 4, is shown in Figs. 7, 8, 9, and 10. The action is different when the surfaces are furrowed, but with furrows much smaller in proportion to the grain than before. Fig. 11 shows a cross section of a pair of grooved rolls, such as are used for breaking corn in high milling break rolls. The roll, *b*, is supposed to travel twice as fast as the roll, *a*. It will be seen that



the grains of corn are held on the furrows of *a*, and are sheared off by the sharp edges of *b*. The action of the beaters in the paper pulp machines is somewhat similar. The edges of the acting surfaces of these machines are shown in cross section, Figs. 12 to 14. If the bundles of fibers lie across the edges, a pinching action will result; if the distance apart of the beaters be sufficient, and the disk be moved, the friction will tear apart the fibers—Fig. 14—and the separation will take place along the weakest place. In order that grinding surfaces may give the necessary friction to tear apart

the bodies to be ground, they have generally to be artificially roughened.

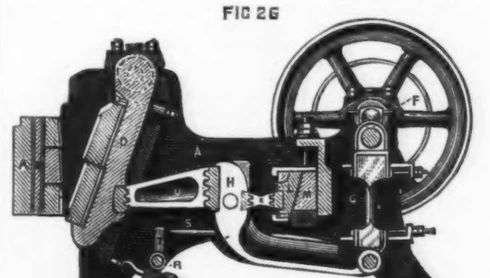
In Zippser's wheat cutting machines—Figs. 15 and 16—the rolls are formed of alternate saws and distance pieces, and are run at different speeds; the body is broken on three points—Fig. 16. Stone-breakers belong to the class of machines with vibrating jaws. It is necessary that the material as it becomes broken should fall away from the acting place. The simplest way is by the weight of the material. Stamping mills with a revolving drum are used in Belgium for reducing fire clay—Fig. 17; the reduced fire clay is helped away by the motion of the drum. When the outgoing material is forced onward by the grinding surfaces, there is doubtless much loss of power and capacity for doing work, yet this means is very usual—for example, dry stamping mills and the usual millstones; but with regard to the latter, there is a great difference in the action of over and under running millstones. Broken corn, "Schrot," will safely run



down an incline of 45 deg.; fine flour requires a much steeper angle; whole corn a less steep angle, so that 45 deg. may be taken as the mean. The frictional resistance of the just mentioned materials is sensibly equal to the weight. Taking 120 revolutions per minute as the average speed for the under running stone, the throwing out force *s*, the radius *r*,

then $$S = \frac{m \cdot v^2}{r} = \frac{G}{g} \cdot r \left(\frac{2 \cdot \pi \cdot 120}{60}\right)^2$$

where m=the mass of the body, G the weight, g t e well known number 9·81, v the periphery speed corre-

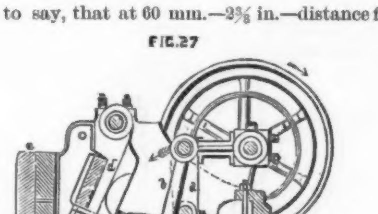


sponding to the radius, r; then, if the throwing-out force equals the weight of the separated particles,

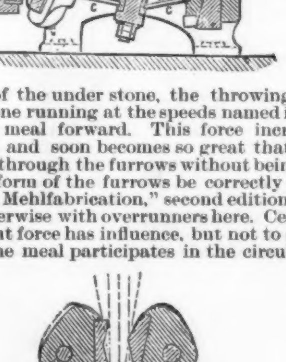
$$\frac{G}{g} \cdot r \left(\frac{2 \cdot \pi \cdot 120}{60}\right)^2 = G$$

$$r = \left(\frac{1}{4\pi}\right)^2 g = G$$

that is to say, that at 60 mm.—2⅜ in.—distance from



the center of the under stone, the throwing-out force with the stone running at the speeds named is sufficient to send the meal forward. This force increases with the radius, and soon becomes so great that the meal will fly out through the furrows without being reduced, unless the form of the furrows be correctly designed—Kick, "Die Mehlfabrication," second edition, p. 137. It is quite otherwise with overrunners here. Certainly the throwing-out force has influence, but not to so great an extent, as the meal participates in the circular motion



of the upper stone as they lie on the fixed lower stone; the forwarding action is also due to the crossing of the furrows. Much discussion has been expended on the best form and position of the furrows, but of late years this has been found to be of secondary importance, and has been thoroughly entered into by Professor Kick—*op. cit.*

To assist the exit of the reduced material from the sphere of action, water has been used, for example, in ore stamping, paper making, etc., and currents of air have been used with advantage in corn grinding, for the twofold purpose of forwarding the meal and for keeping it cool. According to Kick ("Geretz der Pro-

portional Widerstande," 1885, p. 1), the effective power used is independent of the method employed. The mechanical work used by the machine varies between wide limits, the friction of the machine itself greatly varies, and so also does the internal friction of the body to be reduced. Unfortunately, very few, if any, data are to hand as to the power required. Such experiments are both costly and troublesome.

In breaking up a body with machines with vibrating jaws, such as Blake's stone breaker, the action is not purely that of crushing, it is more of the kind represented in Fig. 16, the breaking on three points, as the jaws are usually furnished with corrugations, or rather

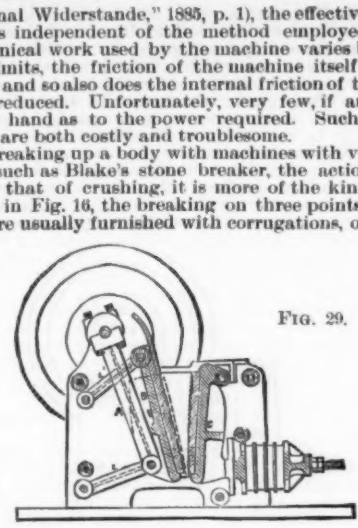
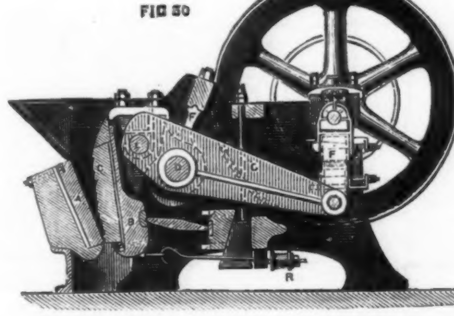


FIG. 29.

with wavy surfaces. These machines were invented by Eli Whitney Blake, of New Haven, Conn., U. S. A., in the year 1858. In the oldest form the motion was given to the jaw by a crank acting on a knee lever by means of a link, a double-armed lever, and a thrust rod. Later, the link acted directly on the knee lever. Other varieties of lever arrangements have been used, of which more will be said anon, and we will first describe the jaws themselves. Fig. 18 shows a cross section of one form of jaw; *a* is the fixed, *b* the vibrating jaw. The angle, *a*, must be such as to prevent the material from being thrown out upward. Sometimes the angle is as great as 27 deg., so that the value of friction must be about 0·24. With such an angle there is danger to the workmen of pieces being thrown out. A smaller angle, about 20 deg., is found to be safer. On observing Fig. 18, it will be seen that as the jaw moves for-

FIG 30



ward, any point in its surface on the line, *a b*, will also move slightly upward, this upward motion arising from the position of the center of motion. A slight rolling or gliding action of the body on the surface will result from this motion, so that the whole of the motion will not be used in pressure on the material. Fig. 21 shows a different position of the center of motion. Here it is situated at the bottom of the movable jaw, so that instead of tending to move the material upward, there is a slight tendency to move it downward; but it will be seen that in such an arrangement as in Fig. 20, the entrance of the material is somewhat hindered; but this is obviated by placing the center of motion as in Fig. 21. This arrangement is used by Dykhoff, Mehler, and Malter.

Mehler's machine is shown in cross section in Fig. 22, and an outline of George Malter's in Fig. 23. The form of jaw with regard to the nature of the surface to pro-

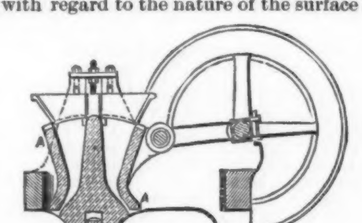
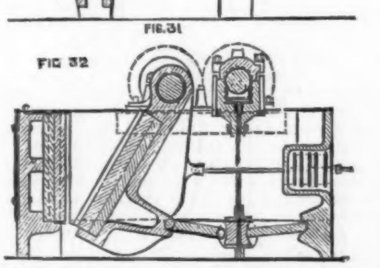


FIG. 31

FIG 32



duce a more or less pure crushing action is important. Quite smooth surfaces are now rarely used. The surfaces are usually made with longitudinal waves or corrugations. Cross sections are shown in Figs. 24 and 25. A slight difference in the form of the corrugations makes a considerable difference in the action. The first cross section, Fig. 24, is suitable for brittle substances, and the second form, Fig. 25, is suitable for angular road metal, with furrows or corrugations 65 mm., 2½ in., pitch, 12 mm., ½ in., deep. A shivering action is given, but with 20 mm., 13/16 in., deep less small stuff is made. The wear of the jaws is considerable, so that it is usual to make them removable and of the hardest possible material, such as chilled cast iron. The distance between the jaws at the top naturally determines the size of the pieces which the machine will take, and the distance between them at the bottom the size of the broken pieces; this distance is adjustable to 20 mm., 13/16 in. The stroke of the movable jaw at the bottom is about 5 to 15 mm.—⅛ in. to ½ in. The knee lever or toggle is the most usual means of transmitting the motion to the jaw, but as it will only give pressure in one direction, a spring is provided to bring the jaw back. Sometimes, however, levers have been introduced to bring the jaw back, ostensibly for saving the loss of power in compressing the spring. The knee lever has been much varied. The newest

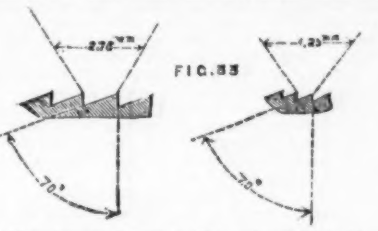
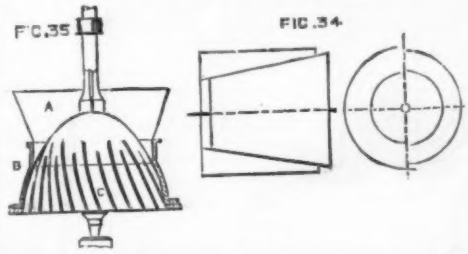


FIG. 33

form of Marsden is shown in the section, Fig. 26. The crank shaft, F, acts on the lever, H, by means of the connecting-rod, G; the axis of the lever, H, is supported in the frame in one direction only, that is, vertically, but is free to move horizonally, and is adjusted by the wedge blocks, L and M, against which one end of the piece, X, rests: the other end of X rests on the lever, H; the toggle, U, transmits the motion to the jaw, D, and gives many small supplementary blows during the forward motion of the jaw, and is supposed to imitate the action of hand breaking, but there does not seem to be any proof of this similarity in the motion. The cheek plates are inserted in the movable jaw in the usual manner, and are held in the fixed jaw by the plate, B. The return motion of the movable jaw is given by a rod and lever, and is equalized by rubber buffer, W. A machine of this kind, with the mouth 200 mm. by 380 mm.—8 in. by 15 in.—running at 250 revolutions per minute, will break 6 tons of the hardest basalt—to what size is not given—per hour, and requires 4 horse power.

Another unusual system of levers by Baxter is shown in Fig. 27. The connecting rod is attached to the upper end of an arm, *a*, swinging at its lower end on a fixed bolt; the rod, *b*, is also attached to the upper end of *a*; the toggles, *c c*, lie in the lower end of *b*. It will be

FIG. 35 FIG. 34



easily seen that the movable jaw will approach the fixed jaw, *e*, with a jumping motion; but simplicity is certainly not a characteristic of this machine, whatever the advantages of the complex motion may be. Bigge arranges the lever so that it receives motion from both above and below, thus giving twice as many blows as the crank makes revolutions.

The practical value of these stone breakers consists in their capability of breaking down large lumps of hard material into small pieces of the size of walnuts, or even hazelnuts, and it is not fair to treat them as capable of doing anything further, and they are often successfully used for reducing large pieces to a size suitable for further reduction by other more refined machines. The power required and amount turned out is shown in the next table.

From the Actien-Gesellschaft Humboldt, Kalk, near Cologne.

Number of machine.		1	2	3	4	5	6	7	8
Size of mouth in inches	length	4	6⅝	8	9⅞	12⅝	15¾	19⅝	31½
	breadth	2	3⅛	4	5	6¾	7⅞	9⅞	19⅝
Driving pulley in inches	diam.	10¼	12⅝	15¾	18⅞	21⅝	24⅞	27½	39⅜
	width	2¾	3⅛	3½	3⅞	4⅞	5⅛	5⅛	7⅞
Vibrations per minute		50	50	200	200	200	200	200	200
Horse power required		0·1	0·2	2	3	5	7	9	16
Hourly turnout in tons	1 in.*	0·05	0·1	1	1·5	2·25	3·5	5	10
	2 in.	0·1	0·2	2	3	4·5	7	10	20
Space occupied by machine in inches	length	44	56	60	67	75	85	98	133
	breadth	52	60	44	49	48	65	75	93

* Width of opening between jaws at bottom, or size of pieces.

C. Mehler's Stone Breaker, Aachen.

Number of machine.		1	2	3	4
Size of mouth in inches	length	23⅝	17¾	12⅝	6⅝
	breadth	13	8⅝	6¾	3⅛
Driving pulley in inches	diam.	23⅝	15¾	11⅞	9⅞
	width	6	4¾	4	3⅛
Speed per minute		200	200	200	200
Horse power required		12 to 14	8—10	4—6	1—2
Hourly turnout in tons	size of pieces produced 1 in.	6	4	2·5	0·6
	2 in.	12	8	5	1·2
Space occupied by machine in inches	length	85	70	56	44
	width	56	[illegible]	39	31

Pulverizing may be effected by combined shearing and rubbing. Alden's ore breaker, the jaws of which are shown in section, Fig. 28, has a peculiar action. The jaws are swung on fixed bolts, *a a*, at the top, and are connected together at the bottom by a link. Motion is given to the link by a crank and connecting rod, so that the jaws move backward and forward through small angles. This motion gives a rubbing action, and the machine is used to reduce ores to fine powder, but it must be difficult to produce an even result. Gardiner's and Bullock's machines are similar, and Wolf has introduced the arrangement shown in Fig. 29. The connecting rod, *a*, moves the jaw, *b*, the link, *l*, carries it toward the jaw, *c*, behind which a buffer is placed to allow of the accidental entrance of an unbreakable piece to move this jaw back so as to avoid risk of breakage. Marsden has attained very nearly the same motion, but in a more durable manner, by the arrangement shown in Fig. 30. The connecting rod, F, transmits the motion of the crank, P, to the lever, C, which swings on the strong bolt, D, the friction is reduced by the link, I, the lever, C, takes hold of the jaw, B, by the bolt, E, and gives it a kind of circular motion; the jaw, B, is supported against a toggle resting against an adjustable block; a complex up and down to and fro motion is thus given to the jaw, B. A machine of this kind with a mouth 380 mm. by 180 mm.—15 in. by 7 in. —running at 250 revolutions per minute, will break 6 tons of the hardest basalt per hour, using 4 horse power. Huet's stone breaker has jaws moved backward and forward, and at the same time are revolved on each other; the work might be much easier done with rolls running at different speeds. Humboldt's machine reminds one of the pestle and mortar—it is shown in Fig. 31—the jaws, *a a*, are in the form of a rectangular box; the action is clearly shown in the figure. The wear and tear in this machine must be very great. Averly's machine, shown in Fig. 32, differs but little from those already described. Other similar machines are those of the Prinz Rudolph Iron Company and of H. Gruson. —*The Engineer.*

MAKING A STREET CABLE.

A SAN FRANCISCO paper gives the following account of the manufacture of a cable as carried on in the engine house of the Market Street Railway, for, contrary to the usual custom of cable roads, this line manufactures its own cables. This cable-making machine is a purely Californian invention, the inventor and patentee being Mr. Henry Root, who, in fact, has invented about everything which has made the Market Street system so nearly perfect. The machine is situated in the extreme rear of the engine house, and runs from the basement clear up among the rafters of the building.

This machine takes a piece of manila rope and 114 wires, and in a few minutes places on the reel, ready for use, a cable of the most approved kind. As the work commences at the basement, or lower deck, a description of the machine properly begins there. An iron column runs up from the foundation to the top of the machine, and in this is carried the ¾ in. manila or hemp rope, which forms the heart of the cable, and gives it "life," that is pliability and elasticity. It will readily be understood by even a novice that if the heart or core of the cable was a wire, it would make the rope stiff, brittle, and hard to handle. Before the manila core enters the column it passes through a box of tar, and becomes thoroughly soaked and saturated, so that it remains impervious to moisture and retains its pliant nature.

In the basement is set the huge gearing which gives the machine its initial motion. Power is furnished from a small engine that looks ridiculously inadequate to do the work, but which, however, twirls the bobbins and spindles around as if they were light as feathers. Passing from the basement to the lower deck or platform, one beholds the beginnings of each strand of the cable. Six upright spindles are arranged about the main column, and each spindle has seven bobbins; a wire from one bobbin is drawn off to form the core of a strand, and around it are twisted the other six wires.

The system of gearing is so contrived as to give to the machine three separate, distinct, and simultaneous motions. The whole machine revolves around the center column; each of the six sections or spindles has an independent twisting motion of its own to form the heart of the strand; each bobbin has an independent motion to take the twist out of the wire as the machine revolves. It is wonderful to watch and note one particular bobbin throughout an entire revolution of the machine. Never does the wire get into the strand with a twist in it. This preserves the life of the wire by preventing the breaking and crushing of the molecules, as would be the case were the wire twisted out of shape. From this lower deck the six cores pass up through hollow columns to another deck, where the strands are completed.

By an arrangement similar to that on the lower deck, twelve bobbins unreel their wires around each core, thus completing the strand. By this it will be seen that each strand of the cable proper contains nineteen wires, seven forming the heart of each strand and twelve laid up around each heart. The work of the seventy-two bobbins on the second deck completes all the strands, and they then pass up over tension wheels to be laid up around the manila rope which is to form the heart of the cable proper. The strands are passed over these tension wheels in order that each may have a uniform strain or tension, and thus avoid any irregularities in the finished rope. The tension wheels are regulated by movable weights on levers, which throw the wheels in or out as may be desired. From the tension wheels the strands lead up and are twisted about the manila heart, and the whole cable then passes up through a die which forces any irregularities there might exist down into the heart of the cable, leaving a smooth, evenly rounded surface and uniform diameter.

This die is not absolutely necessary, but is used as an additional precaution in case the tension wheels should have failed from any cause to maintain a uniform strain. The cable, when it passes through the die, is finally drawn off from the machine by passing over two immense wheels, which are driven by power transmitted from the main shaft on the lower floor by beveled gearing connecting with a shaft on the upper floor, on which is a worm-wheel running in a wheel connecting with the drawing off wheels. These latter wheels draw off the cable so that it retains the tension given it on the machine.

Beside the drawing off wheels is placed a revolution counter, which records the number of yards of cable passing over the top of the wheel. From the drawing-off wheel the cable passes through a box of tar and then down to the lower floor, where it is wound on an enormous spool, ready to be laid in the street, for every-day use. This machine possesses the great advantage of requiring the material to be handled but once to complete the cable. In other cable-making machines the strands are laid up first, and then are

put into another machine to lay up the rope. This machine lays up the strands and makes the rope by a continuous and uninterrupted process.

Superior advantages are also claimed for the cable itself, as it is so compactly twisted that it is well-nigh impossible for a strand or wire to be ripped out. The machine has the capacity of turning off 1,000 ft. of finished cable per day. In making the cable, in order to preserve a uniform diameter, the ends of the wires are carefully brazed together. The length of time which a cable can be used on the Market Street system depends largely on which road it is laid. The cable on Market Street is used by all the cars of the system, the Valencia, McAllister, Hayes, and Haight Street cars. The cable usually lasts about eight months. The average duration of a cable is from six months to two years.

Generally, a cable wears out first where the splice is. A cable in use continually stretches, and this slack is taken up in the engine house by a movable carriage, and when the cable has stretched a certain amount the carriage is moved up, the old splice cut out and a new splice put in, which is expected to last as long as will the cable. The cables made by the Market Street Railway Company are 1¼ in. in diameter and weigh 2⅛ lb. to the foot.

The Market Street rope is 23,858 ft. long; the Valencia Street, 23,700 ft. long; the McAllister Street, 20,580 ft. long; the Hayes Street, 23,385 ft. long; the Haight Street, 20,452 ft. The Fulton Street rope is 5,580 ft. in length, and the auxiliary rope at the Valencia and Market Street curve, 480 ft. long. When a cable is no longer fit for use on the road, it is taken out and sold for old iron to junkmen or whoever wants to buy it.

At 2⅛ lb. to the foot it will be seen that the Market Street cable, which is the longest rope, weighs on the reel nearly thirty tons. If any one who is not familiar with machinery wishes to become hopelessly bewildered, all he has to do is to go under Market Street among the tunnels and chambers full of rambling pulleys and swiftly passing cables where the Valencia Street, Market Street, Haight Street, and the auxiliary ropes come into and go out of the engine house.

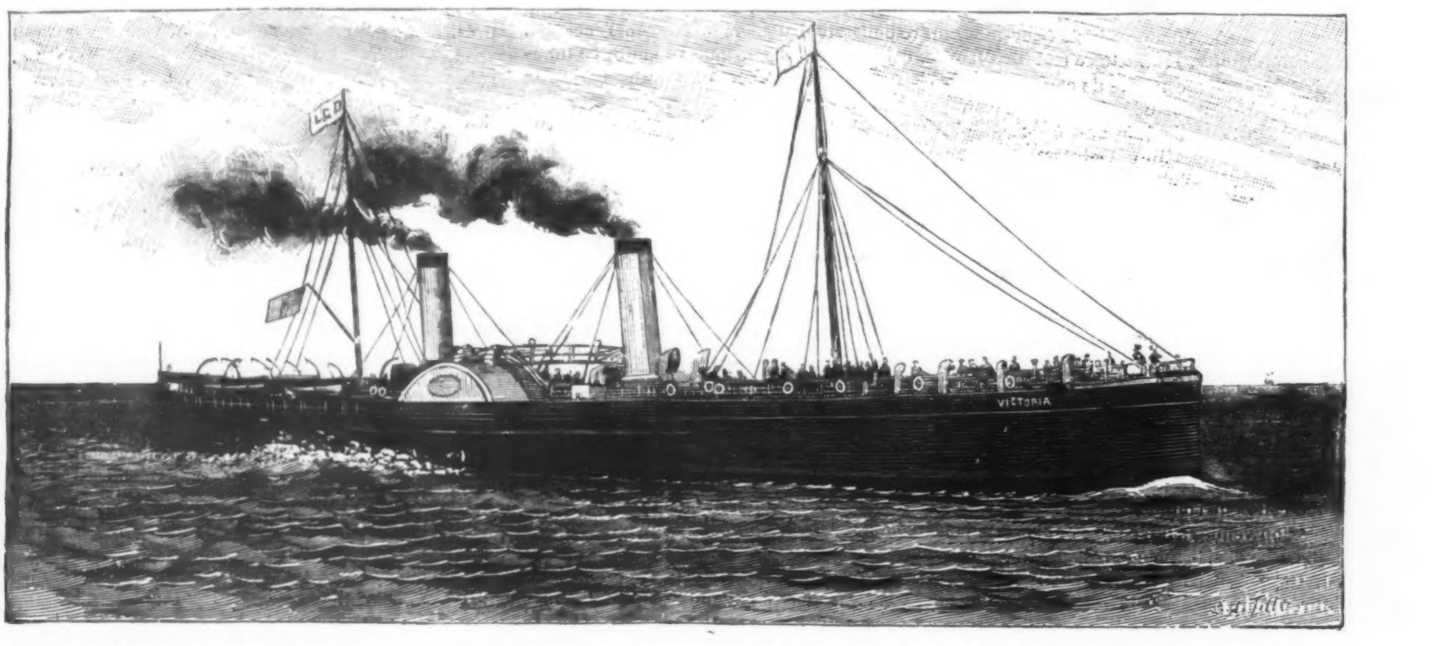
NEW CHANNEL STEAMER VICTORIA.

HERETOFORE, the fastest steamer on the English Channel was the Invicta, which made the passage from Calais to Dover in one hour and ten minutes. It is now quite a different story. The new steamer Victoria has beaten the record of the Invicta, and has accomplished the passage in 54 minutes.

This fast, luxurious, and comfortable boat, which cost $400,000 and is capable of transporting 900 passengers, comes from the yard of John Elder & Co., of Glasgow. It measures 94·25 m. in length and 30 m. beam, draught 2·54 m. Its engines are 5,000 horse power, and can attain 20 knots, or about 37 kilometers, an hour.

The Victoria has five magnificent saloons, one of which is reserved as a sleeping room, 13 handsomely furnished private staterooms, all being illuminated with electric light. Each one of its wheels weighs 38,000 kilos., and their enormous size, overcoming the action of the waves, prevents sea sickness.

The travel, which already amounts to 200,000 annually by the Calais-Dover route (a figure greater than the travel by Boulogne and Dieppe combined), will still more increase, the Victoria connecting each day with the fast trains containing the sleepers of the Company International for Paris, Brussels, Bale, Milan, Rome, Brindisi, Vienna, and Constantinople.—*L'Illustration.*



THE NEW CHANNEL STEAMER VICTORIA, RUNNING BETWEEN CALAIS AND DOVER IN FIFTY-FOUR MINUTES.

STEEL STERN WHEEL STEAMER.

MESSRS. FORRESTT & SON, of Britannia Yard, Millwall, E., and Norway Yard, Limehouse, London, E., have lately constructed for an African river a stern wheel steamer of the following dimensions: Length over all, 75 ft.; breadth, 13 ft. 6 in.; depth, 3 ft., with a draught of only 15 in. with six tons of cargo, fuel, and equipment on board. The hull is built entirely of galvanized Siemens-Martin steel, and is divided into five watertight compartments with steam bilge ejectors to each compartment to discharge any water that might accumulate from leak or otherwise. A wood awning covers the vessel completely, and is supported on galvanized iron stanchions. Accommodation for officials is provided for in a large mahogany deckhouse, on main deck forward of boiler space.

The cabin is luxuriously fitted up with cushioned seats, broad enough to be used as sleeping berths when required; the rest of the furniture is of polished mahogany. The pantry is at the fore end, with all necessary conveniences. The sides of the house are fitted up with venetians instead of glass, to give as much ventilation as possible, with sun blinds outside. There are also curtains all round the vessel to be used at night time. The main deck is of light steel, covered with linoleum. The two balanced rudders aft are connected by an iron rod and worked from a steering gear placed forward of the deckhouse, the steersman being clear of all deck obstructions, and by means of a gong can communicate with the engineer aft at will. There are three cargo hatches—one to each hold—giving every facility for working cargo. The windlass is on the ratchet principle, with hand lever for working anchors. The vessel is fitted all round with galvanized steel wire arrow guards, extending from deck to awning, to protect officers and crew from the frequent attacks of hostile natives. A very compact galley is situated on main deck aft.

The engines are of the high pressure type, cylinders 11 in. diameter by 30 in. stroke, and work direct on the stern paddle-wheels. The paddle-wheels are 8 ft. 6 in. diameter, and so arranged that they may be raised or lowered to suit different draughts of water. The boiler, which is placed amidships, is of the Field vertical type, working pressure 120 lb., and having large heating and grate surface for burning wood fuel. The machinery is capable of indicating 75 horse power, and the speed of vessel, with cargo and equipment on board, ten miles per hour. The vessel was built, machinery fixed on board to the entire satisfaction of the owners and their engineer, taken to pieces and packed in cases of not more than 60 lb. each, with the exception of a few parts of the machinery, and delivered within seven weeks from date of order.

KAPOK: A NEW FIBER.

KAPOK is both a Malayan and Java term for the *Eriodendron anfractuosum* and *Gossampinus alba.* It belongs to the *Bombaceæ* family, of which there are several allied orders known botanically as *Byttneriaceæ, Chlenaceæ,* and *Ternstrœmiaceæ,* to which latter family the *Bombax gossipinum* belongs. Among the most remarkable of the *Bombaceæ* family is the baobab, the largest known tree in the world, whose trunk measures 90 ft. in circumference; the durion of the Indian Archipelago, the most delicious of all fruits; and also the ouatier (*Bombax malabaricum*), so extensively planted in India as a shade tree. In their growth and products there is very little difference, all are intertropical and exogenous, perhaps no trees in the world have a more lofty and imposing appearance. The untutored children of Africa are so struck with the majesty of their appearance that they designate them the god tree, and account it sacrilege to injure them with the ax. They are also remarkable for their splendid inflorescence. Their capsules, on bursting, display a flocculent substance often mistaken by travelers for cotton, and the tree is hence called cotton tree; but as the substance is more silky than cotton, it has been distinguished by the name of silk cotton, or, as more generally known in Eastern and Australian commerce, kapok.

The fiber most imported here is of moderate length, although some varieties are short, remarkably elastic, but, unfortunately, so very tender that it may be said not to possess any staple. It was first brought into notice in Europe on the occasion of the great exhibition of 1851, says *Buchanan's Monthly Register,* an Australian contemporary; but beyond being recommended for upholstery purposes, and in combination with other substances in the manufacture of mixed fabrics, to which there were many practical obstacles, it was generally considered as possessing little or no value. Consequently, it was looked on with distrust, "it was not in the market," "brokers did not know it," no pains were taken with it, and from want of attention the article never gained more than notice. In Holland it grew rapidly into favor, and until the Australian colonies became a customer, that country was the only market for it. At the late Amsterdam Exhibition it shared a much better fate than when exhibited in 1851. It was described as "vegetable wool," commanded considerable notice from all classes, and was valued at a very high figure. The effect of this exhibition was to excite the attention of merchants in Java, India and Ceylon to the article, for almost up to this time its qualities and capabilities remained unknown, or so badly neglected that little or no progress was made in it. Large consignments were made to Europe and to these colonies, but the result, so far as Europe is concerned, placing Holland aside, seems not to have been encouraging. The extraordinary success which has attended its introduction, or, literally speaking, its establishment, into Australian commerce is perhaps, without saying too much, without a parallel, for only those who have tried it know the difficulties of introducing a new article of trade, however good. Traders and manufacturers cling with tenacity to old customs and practices, and have almost a thorough disinclination to entertain new substances or new processes. Hence the rapid and increasing demand for the product is unmistakable evidence of the favorable manner in which it has been received by merchants, the furniture trades, and the general public.

It is now about fifteen years since the first shipment of Java kapok came to this market; but, in consequence of the trade in it at Java being confined to Dutch and native hands, regular shipments were not kept up, and when they did arrive it was only in small lots. Consequently, the trade was so unimportant as not to deserve more than notice here, except a passing reference to one or two eventful facts in connection with it. The price which it fetched in those days must have been different from now, for it is said that the purchasers of the first consignment netted a profit of £7,000 on the transaction. So firmly did it establish itself with the trade on its introduction, that when supplies were not regularly forthcoming they sought out a substitute. Various fibers were experimented upon and much valuable information obtained, till at last the trade settled down to the use of "pulu," from the Sandwich Islands, which grew rapidly into favor; but after a few years' trial, though not until the trade had assumed considerable dimensions, was it found to be totally unfit for bedding and upholstery purposes. In a very short time it went to dust; in fact, it possessed a peculiar property of dry decomposition until nothing was left. Thus pulu had a short but curious history, being of a fibrous, silky substance. It was thought to be of the same order as kapok; but an examination of the plant proved it to be of the *Cibotium* species, a quite distinct family altogether from the *Bombax,* and possessing none of its elasticity and durability. In proof of the lasting qualities of kapok, we have to relate that recently a pillow was shown us by a gentleman in Melbourne who was a non-commissioned officer in the imperial service engaged in the Mahratta war of 1843, who, on noticing the tree, picked sufficient of the fiber to fill a pillow case, which has been in constant use ever since (43 years), and still retains its elasticity and fullness, and who assures us he has found nothing so cool or healthful to sleep on in warm climates as this article. Such testimony is most valuable. It was not until the year of the Melbourne Exhibition (1881) that the first shipments arrived from India and Ceylon. It is difficult to obtain reliable statistics concerning the trade, for there appears to have been a determination, which by some houses is maintained to this day, on the part of shippers and local merchants to keep the whole thing a secret. We find it entered at the local customs under all manner of names, such "vegetable fiber," "vegetable wool," "silk cotton," "tree cotton," "raw cotton," and "Simool cotton." Even now, all the imports from India and Ceylon are entered at the customs either as raw or Simool cotton; only the Java imports are described as kapok.

Tabulating all the values described under the above headings passed through the customs in 1881-82-83, the trade seems not to have been followed up or prosecuted to any great measure of success. It may be said that no decisive and important progress was made with it until the year 1884, when the firm of Messrs. Catherwood, Welsby & Company, of this city, went largely and solely into the trade. Mr. F. A. Catherwood, when passing through Ceylon in 1883, became attracted by the article, and at once perceived its economic uses and the future there must be for it. On returning to Victoria, his firm

entered with zeal upon the trade, and it is due to Mr. Catherwood's foresight and tenacity of purpose, as well, perhaps, as to his firm's enterprising and venturous spirit, for the wonderful development by leaps and bounds the trade has assumed to-day. Not only may it be said with truth that Messrs. Catherwood, Welsby & Company control the market throughout Australia and New Zealand, but also the Java market. Their large purchases abroad are not only felt on the spot, but have a corresponding effect on the market in Holland. Had it not been for the heavy purchases of this Melbourne firm, it would have been a sorry time for both Java and Holland. At the opening of the last season, December, 1884, Holland had stored up in its warehouses 12,000 bales, with a strong "ring" formed by dealers to bear down the market. Both merchants and dealers remained firm. As the season advanced, the latter hoped, in fact expected, shipments would arrive, when merchants would be bound to ease down stocks. They had reckoned without their host. Their action, as is too often the case, was the result of a miscalculation. Other competitors had entered the field abroad. Messrs. Catherwood, Welsby & Company's orders alone for the Australian market amounted to three-fourths of the entire crop. What a relief this must have been to the Dutch merchants, who through the operations on this side of the globe were put in a position to withstand the tactics of the "ring." Some small consignments were made to Holland from Java toward the close of the season.

Stocks, by our last advices from Holland, dated April 27, had worked down to 2,000 bales, so that next season at Java a rise may be looked for. The crop will be keenly competed for by Dutch and Australian houses.

The following comparative table containing statistics for the past three seasons will be found interesting to this part of our subject:

IMPORTATION (IN BALES) OF KAPOK INTO MELBOURNE.

Country.	1884	1885	1886
Java	500	1,300	7,995
Ceylon	86	150	200
India	450	900	650

Note.—A bale of Java kapok average weight is about 80 lb.; a bale of Ceylon about 200 lb.; a bale of Indian about 400 lb.

VALUE OF ENTIRE PRODUCE.

Country.	1884	1885	1886
	£	£	£
Java	1,400	3,700	22,600
Ceylon	430	700	1,000
India	3,750	6,000	3,250

While values have been comparatively steady for the past three seasons, for both the Java and Ceylon article, viz., 8½d. and 6d per lb., free Melbourne, there has been a gradual and serious decline in the value of Indian kapok, receding from 5d. in 1884 to 3d. to-day. It is understood we only allude to merchants' parcels in original bales; the retail trade has not been affected much by the fall. Even at the low price Indian kapok is to-day, the trade find it to their interest to pay 8½d. and higher for Java, than 3d. for the former. The Indian is frequently received in such a filthy condition as to be almost unusable, more than 40 per cent. of the whole being waste—composed of sand, dirt, seeds, etc., which necessitates the bales being sent to a kapok mill to be cleaned and teased, for which the cost of milling is 1d. per lb. on the gross weight put through. On working out the relative values of the Java and Indian article at current market prices, in original bales as above quoted, basing our calculations on the experience of experts, we find that 21 lb. of the Java fill as well as 29 lb. of the Indian in its teased and prepared state, the filling being the true test of respective values, resulting in a percentage of 38 in favor of Java. Therefore manufactured articles of this commodity, filled with the Java, are much lighter and more easy to handle, which is a great desideratum for bedding in warm climates, for which purpose this product, at the present period, is almost solely imported.

At Java the trade has assumed a uniform practice. No unclean stuff is shipped, but the different grades of cleaning denote standard of quality; the first, "extra cleaned," being cleaned by machinery and the first picking of the crop; the second, denoted as "best cleaned picked," being all hand picked and free from seeds, except an odd one here and there; the third is simply designated *cleaned*. It contains a few seeds, together with the "slubs," or little knotty, curly lumps, which are cast aside from the higher grades. Quality of any one class is found most uniform throughout the bales. Packing is all done in straw mats, and never tight pressed; the first quality, "extra cleaned," weighing about 65 lb.; the second and third, from 75 lb. to 90 lb. Bales over 90 lb. to 95 lb., on account of having to be dumped by machinery, destroying the elasticity of the fiber, are reckoned not to be worth within ½d. to 1d. per lb. in value of bales of lesser weight.

In fact, it is a peculiar feature of the Java trade that weight of bales forms an essential condition of price—the lighter the highest, and *vice versa*.

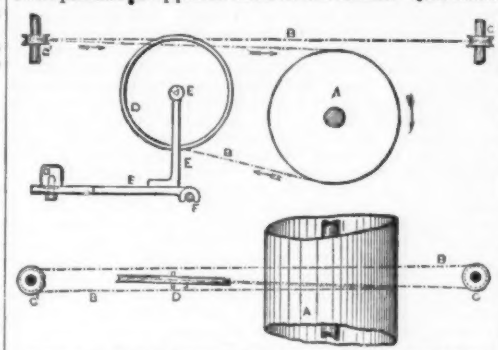
Like most articles, kapok is not without its adulterations, imitations, and frauds. The practice recently brought to our notice of mixing "cotton fly," the refuse of cotton, with it, which is worth in this market only from 1d. to 1½d. per lb., is a gross fraud upon the trade and consumers. Two pounds of the mixture is not equal in filling to ¾ lb. of the true article, besides being devoid of its elasticity, for no vegetable substance is so dead and hard as cotton fly. We have shown the ordinary Hessian bags filled with kapok, as used by the trade. We notice the bags of Indian and Ceylon were alike, 48 lb. A bag was then filled of the Java, especially for us, as the latter is only sold in "the original" straw bales—this weighed 30 lb. Then we were shown a bag of the spurious stuff, which had not even the appearance of fullness as the others we examined, but this to our surprise weighed 72 lb.—it was merely an illustration of weight between kapok and the refuse of cotton mixture. We asked the firm showing it to us how it could be detected. Were the trade aware of the fraud? They replied, very few; they only knew it did not fill so well, meaning it required more to do the same work, and as a consequence would take nothing but the Java, but its real defect was its deadness and lumpy nature.

Kapok has a bright future before it, and there is little doubt that, with the invention of proper carding and spinning machinery, it will be used in the fabrication of articles of clothing, and prove a formidable rival to its allied substances. It has already been used for making gun cotton, a substitute for beaver fur, converted into half stuff for paper making, making silk buttons and fringes, and by the Indians, who make beautiful fabrics of it. In Bombay, the fiber of the bark is used as a substitute for flax, and in Bengal the natives collect the milky juice as a substitute for shellac and gutta-percha. The seeds have almost the same value as cotton seeds, being exported to Europe to extract the oil, and fetch from £3 to £5 per ton.

A kapok mill has been erected by Messrs. Lynas & Gwynne on the Sandridge Road, in Melbourne.

IMPROVED METHOD OF SPINDLE DRIVING.

Mr. Elce, of Manchester, has brought out the device here illustrated, in which a band is used driving two spindles at opposite sides of the frame. The band

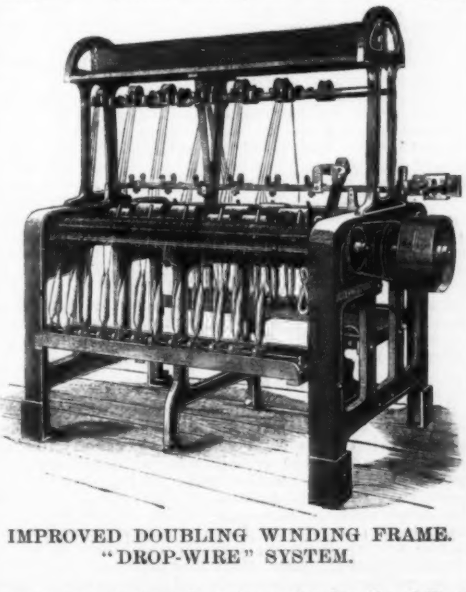


ELCE'S IMPROVED METHOD OF SPINDLE DRIVING.

makes a half turn round each spindle, C, C', embracing a full half of the circumference of the tin roller, *a*, and a bare half of the circumference of a grooved tension pulley, *d*, which is carried by its center pin, *e'*, upon a bent lever, *e*. This bent lever has its bearing at *f*, and at *g* is a balanced weight which serves to maintain a regular, even, and continuous tension upon the driving band, *b*. Thus, with the use of only one tin roller, the band is suitably led on and off the wharves of each spindle, a more than sufficient encirclement of the tin roller is obtained, and by means of the weights, *z*, any desired tension is obtained in every band on the frame, and not only is the yarn produced accurate and even in twist—the greatest desideratum—but the bands last until absolutely worn or frayed out, and need no renewal until this takes place. An immense saving of time and trouble and waste is thus effected; less oil is required, and the production of a frame is increased by the fact that there are fewer idle spindles. Mr. Elce considers that his improvements will be most appreciated by spinners of heavy cotton, worsted, and flax yarns, and doublers of heald yarns.

IMPROVED DOUBLING WINDING FRAME.

The machine illustrated herewith is a doubling winding machine, constructed on what is known as the "drop-wire" system, whereby the automatic stopping



IMPROVED DOUBLING WINDING FRAME. "DROP-WIRE" SYSTEM.

arrangement is brought into action by the fall of wires carried upon the threads, and which, on the breakage of the latter, are liberated. This principle is not new, but Mr. Joseph Stubbs, of Manchester, has devised a new and improved combination of parts and arrangement of details, and has also so improved the construction of the machine that he obtains better results than have been reached before.

The skewer brackets are placed as usual in the bottom box, and these having been supplied with copped skewers the threads are conducted first through the snarl catchers, or cleansing plates, thence over the flannel-covered drag rail, which is so constructed that it can be adjusted with facility to give the amount of drag that may be required. The threads next pass through the drop wires, which are carried in boxes, each box containing as many as may be required for the class of work in hand. The lower part of the drop wires are made double, so as to afford increased strength and prevent bending or breakage. By a novel arrangement the wires are kept in proper position for work; and in the event of their having to be changed for different counts of yarns, all that is necessary can be accomplished in a very short time with facility and ease. Below the line of boxes works a constantly rotating shaft, which upon the breakage of a thread, through the dropped wire and its connections liberates an intermediary tumbler, which permits the bobbin cradle to drop obliquely backward, thereby bringing the bobbin into contact with a brake surface, thus instantly arresting its revolution. The stop-motion is so sensitive and acts so quickly through its various parts that, though the bobbin may be winding yarn at the rate of 5,000 inches per minute or even more, the end of a broken thread will nearly always be found 18 inches in front of the bobbin, which, it will be obvious, precludes the necessity (or even any convenience) on the part of the operative in making bunch knots, which are so detrimental to good work in this class of winding.

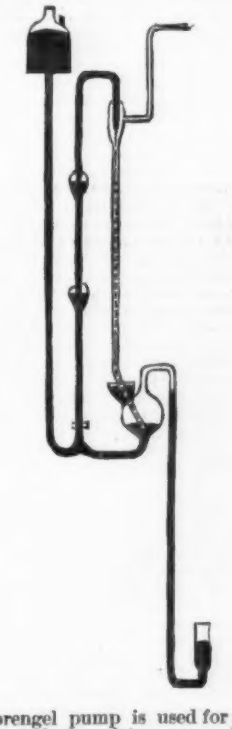
The threads, after passing through the eyelets of the drop wires, are conducted over the wooden carrier-rollers, whence they descend to the bobbin. These rollers, instead of being bracketed to the top cop box as usual, are carried upon a rail. The advantages of this change are that greater steadiness is obtained in the working of the rollers, and the cop box is clear for its legitimate use. The cop box itself is made wider in order to receive the full length of an average sized cop. The machine contains only one row of drums, each drum serving two bobbins. This, with improvements in other details, enables the machine to be constructed so as to occupy much less space than ordinarily they are found to do.

In the construction of this machine, the maker has bestowed special attention upon it in order to make it peculiarly well adapted for winding soft spun, tender, and very fine counts of yarns, for which it is specially recommended. It is carefully and substantially made, and well finished in all its parts, and not easily liable to derangement. On communicating with the maker, our readers may obtain any further information they may desire.—*Textile Manufacturer.*

A MERCURIAL AIR PUMP.*

By J. T. Bottomley.

The primary object of the pump described in this paper is the removal of the mercury which works the pump from contact with the external atmosphere.



When the Sprengel pump is used for producing and maintaining a nearly complete vacuum during a course of experiments which lasts over a good many days or weeks, it is found that the mercury running down through the pump and discharging into the open air takes up minute quantities of air, which it carries with it in a state of very intimate mixture. This intimately mixed air the mercury does not lose in passing through the air traps; but the air is deposited along the walls of the pump head, and collects there into bubbles which, at first exceedingly minute, gradually increase to a sensible size. These bubbles ultimately escape from contact with the glass, and deteriorate the vacuum. The pump described, as will be seen from the diagram, consists of a combination of a single fall Sprengel with a Geissler pump; and in addition the movable reservoir is furnished with an air-tight stop cock, by means of which the air is got rid of from that reservoir and prevented from re-entering.

In using the pump, it is first worked as an ordinary Geissler pump till nearly all the air of the space to be exhausted has been removed. In this way advantage is taken of the comparatively great speed of the Geissler pump.

When a good exhaustion has been obtained, the stop-

* Read before the British Association, 1886.

cocks and the lift of the movable reservoir are so managed that the pump is thereafter used as a Sprengel, the small remaining traces of air being pumped by the Sprengel into the exhausted chamber of the Geissler; and when a sufficient quantity of air has been collected in this chamber, it can be removed by performing a single Geissler operation.

Mr. Bottomley further said he had gone down to about $\frac{1}{50000000}$ of an atmosphere with the McLeod gauge, but of course there was great difficulty in knowing what the indications of the McLeod gauge meant. He could not, however, say how much further he should be able to get with his pump, which had not yet been quite completed.

THE GEOLOGY OF THE ATLANTIC.

THE fifty-sixth annual meeting of the British Association for the Advancement of Science was opened in Birmingham on September 1, when the president, Sir J. William Dawson, C.M.G., M.A., LL.D., F.R.S., F.G.S., principal and vice-chancellor of McGill University, Montreal, delivered an address, from which we extract the following. After some introductory remarks, in which the president referred to the last meeting in Birmingham and the founding of the Mason College, he said:

In a recent address, the late President of the Royal Society called attention to the fact that within the lifetime of the older men of science of the present day, the greater part of the vast body of knowledge included in the modern sciences of physics, chemistry, biology, and geology has been accumulated, and the most important advances made in its application to such common and familiar things as the railway, ocean navigation, the electric telegraph, electric lighting, the telephone, the germ theory of disease, the use of anæsthetics, the processes of metallurgy, and the dyeing of fabrics. Even since the last meeting in this city, much of this great work has been done, and has led to general results of the most marvelous kind. What at that time could have appeared more chimerical than the opening up by the enterprise of one British colony of a shorter road to the East by way of the extreme west, realizing what was happily called by Milton and Cheadle "the new Northwest Passage," making Japan the next neighbor of Canada on the west, and offering to Britain a new way to her Eastern possessions? or than the possibility of this Association holding a successful meeting on the other side of the Atlantic? To have ventured to predict such things in 1865 would have appeared quite visionary, yet we are now invited to meet in Australia, and may proceed thither by the Canadian Pacific Railway and its new lines of steamers, returning by the Suez Canal. To-day this is quite as feasible as the Canadian visit would have been in 1865. It is science that has thus brought the once widely separated parts of the world nearer to each other, and is breaking down those geographical barriers which have separated the different portions of our widely extended British race. Its work in this is not yet complete. Its goal to-day is its starting-point to-morrow. It is as far as at any previous time from seeing the limit of its conquests, and every victory gained is but the opening of the way for a farther advance. By its visits to Canada, the British Association has asserted its imperial character, and has consolidated the scientific interests of Her Majesty's dominions, in advance of that great gathering of the industrial products of all parts of the empire now on exhibition in London, and in advance of any political plans of Imperial federation. There has even been a project before us for an international scientific convention, in which the great English republic of America shall take part, a project the realization of which was to some extent anticipated in the fusion of the members of the British and American Associations at Montreal and Philadelphia in 1884. As a Canadian, as a past president of the American Association, and now honored with the presidency of this Association, I may be held to represent in my own person this scientific union of the British Islands, of the various colonies, and of the great Republic, which, whatever the difficulties attending its formal accomplishment at present, is certain to lead to an actual and real union for scientific work. In furtherance of this I am glad to see here to-day influential representatives of most of the British colonies, of India, and of the United States. We welcome here also delegates from other countries, and though the barrier of language may at present prevent a larger union, we may entertain the hope that Britain, America, India, and the colonies, working together in the interests of science, may ultimately render our English tongue the most general vehicle of scientific thought and discovery, a consummation of which I think there are at present many indications. But, while science marches on from victory to victory, its path is marked by the resting-places of those who have fought its battles and assured its advance. In looking back to 1865 there rise before me the once familiar countenances of Phillips, Murchison, Lyell, Forbes, Jeffreys, Jukes, Rolleston, Miller, Spottiswoode, Fairbairn, Gassiot, Carpenter, and a host of others, present in full vigor at that meeting, but no more with us. These were veterans of science; but, alas! many then young and rising in fame are also numbered with the dead. It may be that before another Birmingham meeting many of us, the older members now, will also have passed away. But these men have left behind them ineffaceable monuments of their work, in which they still survive, and we rejoice to believe that, though dead to us, they live in that company of the great and good of all ages who have entered into that unseen universe where all that is high and holy and beautiful must go on accumulating till the time of the restitution of all things. Let us follow their example and carry on their work, as God may give us power and opportunity, gathering in precious stores of knowledge and of thought, in the belief that all truth is immortal, and must go on forever bestowing blessings on mankind. Thus will the memory of the mighty dead remain to us as a power which,

Like a star,
Beacons from the abode where the eternal are.

I do not wish, however, to occupy your time longer with general or personal matters, but rather to take the opportunity afforded by this address to invite your attention to some topics of scientific interest. In attempting to do this I must have before me the warning conveyed by Prof. Huxley, in the address to which I have already referred, that in our time science, like Tarpeia, may be crushed with the weight of the rewards bestowed on her. In other words, it is impossible for any man to keep pace with the progress of more than one limited branch of science, and it is equally impossible to find an audience of scientific men of whom anything more than a mere fraction can be expected to take an interest in any one subject. There is, however, some consolation in the knowledge that a speaker who is sufficiently simple for those who are advanced specialists in other departments, will, of necessity, be also sufficiently simple to be understood by the general public, who are specialists in nothing. On this principle a geologist of the old school, accustomed to a great variety of work, may hope to so scatter his fire as to reach the greater part of the audience. In endeavoring to secure this end, I have sought inspiration from that ocean which connects, rather than separates, Britain and America, and may almost be said to be an English sea—the North Atlantic. The geological history of this depression of the earth's crust, and its relation to the continental masses which limit it, may furnish a theme at once generally intelligible and connected with great questions as to the structure and history of the earth, which have excited the attention alike of physicists, geologists, biologists, geographers, and ethnologists. Sould I, in treating of these questions, appear to be somewhat abrupt and dogmatic, and to indicate rather than state the evidence of the general views announced, I trust you will kindly attribute this to the exigencies of a short address.

THE GEOLOGY OF THE ATLANTIC.

If we imagine an observer contemplating the earth from a convenient distance in space, and scrutinizing its features as it rolls before him, we may suppose him to be struck with the fact that eleven-sixteenths of its surface are covered with water, and that the land is so unequally distributed that from one point of view he would see a hemisphere almost exclusively oceanic, while nearly the whole of the dry land is gathered in the opposite hemisphere. He might observe that the great oceanic area of the Pacific and Antarctic Oceans is dotted with islands—like a shallow pool with stones rising above its surface—as if its general depth were small in comparison with its area. He might also notice that a mass or belt of land surrounds each pole, and that the northern ring sends off to the southward three vast tongues of land and of mountain chains, terminating respectively in South America, South Africa, and Australia, toward which feebler and insular processes are given off by the Antarctic continental mass. This, as some geographers have observed, gives a rudely three-ribbed aspect to the earth, though two of the three ribs are crowded together and form the Europ-asian mass or double continent, while the third is isolated in the single continent of America. He might also observe that the northern girdle is cut across, so that the Atlantic opens by a wide space into the Arctic Sea, while the Pacific is contracted toward the north, but confluent with the Antarctic Ocean. The Atlantic is also relatively deeper and less cumbered with islands than the Pacific, which has the higher ridges near its shores, constituting what some visitors to the Pacific coast of America have not inaptly called the "back of the world," while the wider slopes face the narrower ocean, into which for this reason the greater part of the drainage of the land is poured. The Pacific and Atlantic, though both depressions or flattenings of the earth, are, as we shall find, different in age, character, and conditions; and the Atlantic, though the smaller, is the older, and from the geological point of view, in some respects, the more important of the two. If our imaginary observer had the means of knowing anything of the rock formations of the continents, he would notice that those bounding the North Atlantic are in general of great age, some belonging to the Laurentian system. On the other hand, he would see that many of the mountain ranges along the Pacific are comparatively new, and that modern igneous action occurs in connection with them. Thus he might be led to believe that the Atlantic, though comparatively narrow, is an older feature of the earth's surface, while the Pacific belongs to more modern times. But he would note in connection with this that the oldest rocks of the great continental masses are mostly toward their northern ends, and that the borders of the northern ring of land and certain ridges extending southward from it constitute the most ancient and permanent elevations of the earth's crust, though now greatly surpassed by mountains of more recent age nearer the equator. Before leaving this general survey we may make one further remark. An observer looking at the earth from without would notice that the margins of the Atlantic and the main lines of direction of its mountain chains are northeast and southwest and northwest and southeast, as if some early causes had determined the occurrence of elevations along great circles of the earth's surface tangent to the polar circles. We are invited by the preceding general glance at the surface of the earth to ask certain questions respecting the Atlantic. (1) What has at first determined its position and form? (2) What changes has it experienced in the lapse of geological time? (3) What relations have these changes borne to the development of life on the land and in the water? (4) What is its probable future?

THE INTERIOR OF THE EARTH.

Before attempting to answer these questions, which I shall not take up formally in succession, but rather in connection with each other, it is necessary to state as briefly as possible certain general conclusions respecting the interior of the earth. It is popularly supposed that we know nothing of this beyond a superficial crust perhaps averaging 50,000 to 100,000 ft. in thickness. It is true we have no means of exploration in the earth's interior; but the conjoined labors of physicists and geologists have now proceeded sufficiently far to throw much inferential light on the subject, and to enable us to make some general affirmations with certainty; and these it is the more necessary to state distinctly, since they are often treated as mere subjects of speculation and fruitless discussion. (1) Since the dawn of geological science, it has been evident that the crust on which we live must be supported on a plastic or partially liquid mass of heated rock, approximately uniform in quality under the whole of its area. This is a legitimate conclusion from the wide distribution of volcanic phenomena and from the fact that the ejections of volcanoes, while locally of various kinds, are similar in every part of the world. It led to the old idea of a fluid interior of the earth; but this is now generally abandoned, and this interior heated and plastic layer is regarded as merely an under crust. (2) We have reason to believe, as the result of astronomical investigations, that, notwithstanding the plasticity or liquidity of the under crust, the mass of the earth—its nucleus as we may call it—is practically solid and of great density and hardness. Thus we have the apparent paradox of a solid, yet fluid, earth: solid in its astronomical relations, liquid or plastic for the purpose of volcanic action and superficial movements. (3) The plastic sub-crust is not in a state of dry igneous fusion; but in that condition of aqueo-igneous or hydro-thermic fusion which arises from the action of heat on moist substances, and which may either be regarded as a fusion or as a species of solution at a very high temperature. This we learn from the phenomena of volcanic action and from the composition of the volcanic and plutonic rocks, as well as from such chemical experiments as those of Daubree and of Tilden and Shenstone. (4) The interior sub-crust is not perfectly homogeneous, but may be roughly divided into two layers or magmas, as they have been called; an upper, highly silicious or acidic, of low specific gravity and light colored, and corresponding to such kinds of plutonic and volcanic rocks as granite and trachyte; and a lower, less silicious or more basic, more dense, and more highly charged with iron, and corresponding to such igneous rocks as the dolerites, basalts, and kindred lavas. It is interesting here to note that this conclusion, elaborated by Durocher and Von Waltershausen, and usually connected with their names, appears to have been first announced by John Phillips in his "Geological Manual," and as a mere common sense deduction from the observed phenomena of volcanic action and the probable results of the gradual cooling of the earth. It receives striking confirmation from the observed succession of acidic and basic volcanic rocks of all geological periods and in all localities. It would even seem, from recent spectroscopic investigations of Lockyer, that there is evidence of a similar succession of magmas in the heavenly bodies, and the discovery by Nordenskiold of native iron in Greenland basalts affords a probability that the inner magma is in part metallic. (5) Where rents or fissures form in the upper crust, the material of the lower crust is forced upward by the pressure of the less supported portions of the former, giving rise to volcanic phenomena either of an explosive or quiet character, as may be determined by contact with water. The underlying material may also be carried to the surface by the agency of heated water, producing those quiet discharges which Hunt has named crenitic. It is to be observed here that explosive volcanic phenomena, and the formation of cones, are, as Prestwich has well remarked, characteristic of an old and thickened crust; quiet ejection from fissures and hydro-thermal action may have been more common in earlier periods and with a thinner over crust. (6) The contraction of the earth's interior by cooling, and by the emission of material from below the under crust, has caused this crust to press downward, and therefore laterally, and so to effect great bends, folds, and plications; and these modified subsequently by surface denudation constitute mountain chains and continental plateaus. As Hall long ago pointed out, such lines of folding have been produced more especially where thick sediments had been laid down on the sea bottom. Thus we have here another apparent paradox—namely, that the elevations of the earth's crust occur in the places where the greatest burden of detritus has been laid down upon it, and where consequently the crust has been softened and depressed. We must beware, in this connection, of exaggerated notions of the extent of contraction and of crumpling required to form mountains. Bonney has well shown, in lectures delivered at the London Institution, that an amount of contraction almost inappreciable in comparison with the diameter of the earth would be sufficient; and that as the greatest mountain chains are less than $\frac{1}{1600}$ of the earth's radius in height, they would on an artificial globe 1 ft. in diameter be no more important than the slight inequalities that might result from the paper gores overlapping each other at edges. (7) The crushing and sliding of the over crust implied in these movements raise some serious questions of a physical character. One of these relates to the rapidity or slowness of such movements, and the consequent degree of intensity of the heat developed, as a possible cause of metamorphism of rocks. Another has reference to the possibility of changes in the equilibrium of the earth itself as resulting from local collapse and ridging. These questions in connection with the present dissociation of the axis of rotation from the magnetic poles, and with changes of climate, have attracted some attention, and probably deserve further consideration on the part of the physicists. In so far as geological evidence is concerned, it would seem that the general association of crumpling with metamorphism indicates a certain rapidity in the process of mountain making, and consequent development of heat; and the arrangement of the older rocks around the Arctic basin forbids us from assuming any extensive movement of the axis of rotation, though it does not exclude changes to a limited extent. I hope that Professor Darwin will discuss these points in his address to the Physical Section. I wish to formulate these principles as distinctly as possible, and as the result of all the long series of observations, calculations, and discussions since the time of Werner and Hutton, and in which a vast number of able physicists and naturalists have borne a part, because they may be considered as certain deductions from our actual knowledge and because they lie at the foundation of a rational physical geology. We may popularize these deductions by comparing the earth to a drupe or stone fruit, such as a plum or peach, somewhat dried up. It has a large and intensely hard stone and kernel, a thin pulp made up of two layers, an inner more dense and dark colored, and an outer less dense and light colored. These constitute the under crust. On the outside it has a thin membrane or over crust. In the process of drying it has slightly shrunk, so as to produce ridges and hollows of the outer crust, and this outer crust has cracked in some places, allowing portions of the pulp to ooze out—in some of these its lower dark substance, in others its upper and lighter material. The analogy extends no further, for there is nothing in our withered fruit to represent the oceans occupying the lower parts

of the surface or the deposits which they have laid down. Keeping in view these general conclusions, let us now turn to their bearing on the origin and history of the North Atlantic.

THE BASIN OF THE ATLANTIC.

Though the Atlantic is a deep ocean, its basin does not constitute so much a depression of the crust of the earth as a flattening of it, and this, as recent soundings have shown, with a slight ridge or elevation along its middle, and banks or terraces fringing the edges, so that its form is not so much that of a basin as that of a shallow plate with its middle a little raised. Its true, permanent margins are composed of portions of the over crust folded, ridged up, and crushed, as if by lateral pressure emanating from the sea itself. We cannot, for example, look at a geological map of America without perceiving that the Appalachian ridges, which intervene between the Atlantic and the St. Lawrence valley, have been driven bodily back by a force acting from the east, and that they have resisted this pressure only where, as in the Gulf of St. Lawrence and the Catskill region of New York, they have been protected by outlying masses of very old rocks, as, for example, by that of the island of Newfoundland and that of the Adirondack Mountains.

The admirable work begun by my friend and fellow-student, Prof. James Nicol, followed up by Hicks, Lapworth, and others, and now, after long controversy, fully confirmed by the recent observations of the geological survey of Scotland, has shown the most intense action of the same kind on the east side of the ocean in the Scottish highlands and the more widely distributed Eozoic rocks of Scandinavia may be appealed to in further evidence of this. If we now inquire as to the cause of the Atlantic depression, we must go back to a time when the areas occupied by the Atlantic and its bounding coasts were parts of a shoreless sea in which the earliest gneisses or stratified granites of the Laurentian age were being laid down in vastly extended beds.

These ancient crystalline rocks have been the subject of much discussion and controversy; and as they constitute the lowest and probably the firmest part of the Atlantic sea-bed, it is necessary to inquire as to their origin and history. Dr. Bonney, the late president of the Geological Society, in his anniversary address, and Dr. Sterry Hunt, in an elaborate paper communicated to the Royal Society of Canada, have ably summed up the hypotheses as to the origin of the oldest Laurentian beds. At the bases of these hypotheses lies the admission that the immensely thick beds of orthoclase gneiss, which are the oldest stratified rocks known to us, are substantially the same in composition with the upper or siliceous magma or layer of the under crust.

They are, in short, its materials either in their primitive condition or merely rearranged. One theory considers them as original products of cooling, owing their lamination merely to the successive stages of the process. Another view refers them to the waste and rearrangement of the materials of a previously massive granite. Still another holds that all our granites really arise from the fusion of old gneisses of originally aqueous origin; while a fourth refers the gneisses themselves to molecular changes effected in granite by pressure.

These several views, in so far as they relate to the oldest or fundamental Laurentian gneiss, may be arranged under the following heads: (1) *Endoplutonic*, or that which regards all the old gneisses as molten rocks cooled from without inward in successive layers. (2) *Exoplutonic*, or that which considers them as made up of matter ejected from below the upper crust in the manner of volcanic action. (3) *Metamorphic*, which supposes the old gneisses to arise from the crystallization of detrital matter spread over the sea-bottom, and either igneous or derived from the decay of igneous rocks. (4) *Chaotic* or *Thermo-chaotic*, or the theory of deposit from the turbid waters of a primeval ocean either with or without the aid of heat. In one form this was the old theory of Werner. (5) *Crenitic* or *Hydro-thermic*, which supposes the action of heated waters penetrating below the crust to be constantly bringing up to the surface mineral matters in solution and depositing these so as to form feldspathic and other rocks.

It will be observed, in regard to these theories, that none of them supposes that the old gneiss is an ordinary sediment, but that all regard it as formed in exceptional circumstances, these circumstances being the absence of land and of sub-aerial decay of rock, and the presence wholly or principally of the material of the upper surface of the recently hardened crust. This being granted, the question arises, Ought we not to combine these several theories, and to believe that the cooling crust has hardened in successive layers from without inward; that at the same time fissures were locally discharging igneous matter to the surface; that matter held in suspension in the ocean and matter held in solution by heated waters rising from beneath the outer crust were mingling their materials in the deposits of the primitive ocean? It would seem that the combination of all these agencies may safely be invoked as causes of the pre-Atlantic deposits. This is the eclectic position which I endeavored to maintain in my address before the Minneapolis meeting of the American Association in 1883, and which I still hold to be in every way probable.

METAMORPHISM.

A word here as to metamorphism, a theory which, like many others, has been first run to death and then discredited, but which, to the moderate degree in which it was originally held by Lyell, is still valid. Nothing can be more certain than that the composition of the Laurentian gneisses forbids us to suppose that they can be ordinary sediments metamorphosed. They are rocks peculiar in their origin, and not paralleled unless exceptionally in later times. On the other hand, they have undoubtedly experienced very important changes, more especially as to crystallization, the state of combination of their ingredients, and the development of disseminated minerals; and while this may in part be attributed to the mechanical pressure to which they have been subjected, it requires also the action of hydrothermic agencies. Any theory which fails to invoke both of these kinds of force must necessarily be partial and imperfect.

But all metamorphic rocks are not of the same character with the gneisses of the Lower Laurentian. Even in the Middle and Upper Laurentian we have metamorphic rocks, *e. g.*, quartzite and limestone, which must originally have been ordinary aqueous deposits. Still more in the succeeding Huronian and its associated series of beds, and in the Lower Palæozoic, local metamorphic change has been undergone by rocks quite similar to those which in their unaltered state constitute regular sedimentary deposits. In the case of these later rocks, it is to be borne in mind that, while some may have been of volcanic origin, others may have been sediments rich in undecomposed fragments of silicates. It is a mistake to suppose that the ordinary decay of stratified siliceous rocks is a process of kaolinization so perfect as to eliminate all alkaline matters. On the contrary, the fact, which Judd has recently well illustrated in the case of the mud of the Nile, applies to a great number of similar deposits in all parts of the world, and shows that the finest sediments have not always been so completely lixiviated as to be destitute of the basic matters necessary for their conversion into gneiss, micaschist, and similar rocks when the necessary agencies of metamorphism are applied to them, and this quite independently of any extraneous matters introduced into them by water or otherwise. Still, it must be steadily kept in view that many of the old pre-Cambrian crystalline rocks must have been different originally from those succeeding them, and that consequently these last, even when metamorphosed, present different characters. I may remark here that, though a palæontologist rather than a lithologist, it gives me great pleasure to find so much attention now given in this country to the old crystalline rocks, and to their study microscopically and chemically as well as in the field, a work in which Sorby and Allport were pioneers. As a pupil of the late Prof Jameson, of Edinburgh, my own attention was early attracted to the study of minerals and rocks as the stable foundations of geological science; and as far back as 1841 I had learnt of the late Mr. Sanderson, of Edinburgh, who worked at Nicol's sections, how to slice rocks and fossils; and since that time I have been in the habit of examining everything with the microscope. The modern developments in this direction are therefore very gratifying to me, even though, as is natural, they may sometimes appear to be pushed too far or their value overestimated. That these old gneisses were deposited not only in what is now the bed of the Atlantic, but also on the great continental areas of America and Europe, any one who considers the wide extent of these rocks represented on the map recently published by Prof. Holl can readily understand. It is true that Holl supposes that the basin of the Atlantic itself may have been land at this time, but there is no evidence of this, more especially as the material of the gneiss could not have been detritus derived from sub-aerial decay of rock.

THE COOLING OF THE EARTH.

Let us suppose, then, the floor of old ocean covered with a flat pavement of gneiss, or of that material which is now gneiss; the next question is, How and when did this original bed become converted into sea and land? Here we have some things certain, others most debatable. That the cooling mass, especially if it was sending out volumes of softened rocky material, either in the exoplutonic or in the crenitic way, and piling this on the surface, must soon become too small for its shell, is apparent; but when and where would the collapse, crushing, and wrinkling inevitable from this cause begin? Where they did begin is indicated by the lines of mountain chains which traverse the Laurentian districts; but the reason why is less apparent. The more or less unequal cooling, hardening, and conductive power of the outer crust we may readily assume. The driftage unequally of water-borne detritus to the southwest by the bottom currents of the sea is another cause, and, as we shall soon see, most effective.

Still another is the greater cooling and hardening of the crust in the polar regions, and the tendency to collapse of the equatorial protuberance from the slackening of the earth's rotation. Besides these, the internal tides of the earth's substance at the times of solstice would exert an oblique pulling force on the crust, which might tend to crack it along diagonal lines. From whichever of these causes, or the combination of the whole, we know that within the Laurentian time folded portions of the earth's crust began to rise above the general surface in broad belts running from N. E. to S. W. and from N. W. to S. E., where the older mountains of Eastern America and Western Europe now stand, and that the subsidence of the oceanic areas allowed by this crumpling of the crust permitted other areas on both sides of what is now the Atlantic to form limited tablelands.

This was the beginning of a process repeated again and again in subsequent times, and which began in the Middle Laurentian, when for the first time we find beds of quartzite, limestone, and iron ore, and graphitic beds, indicating that there was already land and water, and that the sea, and perhaps the land, swarmed with animal and plant life of forms unknown to us, for the most part, now. Independently of the questions as to the animal nature of Eozoon, I hold that we know, as certainly as we can know anything inferentially, the existence of these primitive forms of life. If I were to conjecture what were the early forms of plant and animal life, I would suppose that just as in the Palæozic the acrogens culminated in gigantic and complex forest trees, so in the Laurentian the algæ, the lichens, and the mosses grew to dimensions and assumed complexity of structure unexampled in later times, and that in the sea the humbler forms of Protozoa and Hydrozoa were the dominant types, but in gigantic and complex forms. The land of this period was probably limited, for the most part, to high latitudes, and its aspect, though more rugged and abrupt and of greater elevation, must have been of that character which we still see in the Laurentian hills.

The distribution of this ancient land is indicated by the long lines of old Laurentian rock extending from the Labrador coast and the north shore of the St. Lawrence, and along the eastern slopes of the Appalachians in America and the like rocks of the Hebrides, the Western Highlands, and the Scandinavian mountains. A small, but interesting, remnant is that in the Malvern Hills, so well described by Holl. It will be well to note here and to fix on our minds that the ancient ridges of Eastern America and Western Europe have been greatly denuded and wasted since Laurentian times, and that it is along their eastern sides that the greatest sedimentary accumulations have been deposited. From this time dates the introduction of that dominance of existing causes which forms the basis of uniformitarianism in geology, and which had to go on with various and great modifications of detail, through the successive stages of the geological history, till the land and water of the northern hemisphere attained to their present complex structure.

GROWTH OF CONTINENTS AND SEAS.

So soon as we have a circumpolar belt or patches of Eozoic land, and ridges running southward from it, we enter on new and more complicated methods of growth of the continents and seas. Here we are indebted to Le Conte for clearly pointing out that our original Eozoic tracts of continent were in the earliest times areas of deposition, and that the first elevations of land out of the primeval ocean must have differed in important points from all that have succeeded them; but they were equally amenable to the ordinary laws of denudation.

Portions of these oldest crystalline rocks, raised out of the protecting water, were now eroded by atmospheric agents, and especially by the carbonic acid then existing in the atmosphere perhaps more abundantly than at present, under whose influence the hardest of the gneissic rocks gradually decay. The Arctic lands were subjected in addition to the powerful mechanical force of frost and thaw. Thus every shower of rain and every swollen stream would carry into the sea the products of the waste of land, sorting them into fine clays and coarser sands; and the cold currents which cling to the ocean bottom, now determined in their courses, not merely by the earth's rotation, but also by the lines of folding on both sides of the Atlantic, would carry southwestward, and pile up in marginal banks of great thickness, the debris produced from the rapid waste of the land already existing in the Arctic regions. The Atlantic, opening widely to the north, and having large rivers pouring into it, was especially the ocean characterized, as time advanced, by the prevalence of these phenomena. Thus throughout the geological history it has happened that, while the middle of the Atlantic has received merely organic deposits of shells of Foraminifera and similar organisms, and this probably only to a small amount, its margins have had piled upon them beds of detritus of immense thickness.

Prof. Hall, of Albany, was the first geologist who pointed out the last cosmic importance of these deposits, and that the mountains of both sides of the Atlantic owe their origin to these great lines of deposition, along with the fact, afterward more fully insisted on by Rogers, that the portions of the crust which received these masses of debris became thereby weighted down and softened, and were more liable than other parts to lateral crushing.

Thus in the later Eozoic and early Palæozoic times, which succeeded the first foldings, of the oldest Laurentian, great ridges were thrown up, along the edges of which were beds of limestone, and on their summits and sides thick masses of ejected igneous rocks. In the bed of the central Atlantic there are no such accumulations. It must have been a flat, or slightly ridged, plate of the ancient gneiss, hard and resisting, though perhaps with a few cracks, through which igneous matter welled up, as in Iceland and the Azores in more modern times.

In this condition of things we have causes tending to perpetuate and extend the distinctions of ocean and continent, mountain and plain, already begun; and of these we may more especially note the continued subsidence of the areas of greatest marine deposition. This has long attracted attention, and affords very convincing evidence of the connection of sedimentary deposit as a cause with the subsidence of the crust. We are indebted to a French physicist, M. Faye, for an important suggestion on this subject. It is that the sediment accumulated along the shores of the ocean presented an obstacle to radiation, and consequently to cooling of the crust, while the ocean floor, unprotected and unweighted, and constantly bathed with currents of cold water, having great power of convection of heat, would be more rapidly cooled, and so would become thicker and stronger. This suggestion is complementary to the theory of Professor Hall, that the areas of greatest deposit on the margins of the ocean are necessarily those of greatest folding and consequent elevation.

We have thus a hard, thick, resisting ocean-bottom, which, as it settles down toward the interior, under the influence of gravity, squeezes upward and folds and plicates all the soft sediments deposited on its edges. The Atlantic area is almost an unbroken cake of this kind. The Pacific area has cracked in many places, allowing the interior fluid matter to ooze out in volcanic ejections. It may be said that all this supposes a permanent continuance of the ocean basins, whereas many geologists postulate a mid-Atlantic continent to give the thick masses of detritus found in the older formations both in Eastern America and Western Europe, and which thin off in proceeding into the interior of both continents. I prefer, with Hall, to consider these belts of sediment as in the main the deposits of northern currents, and derived from Arctic land, and that like the great banks of the American coast at the present day, which are being built up by the present Arctic current, they had little to do with any direct drainage from the adjacent shore.

We need not deny, however, that such ridges of land as existed along the Atlantic margins were contributing their quota of river-borne material, just as on a still greater scale the Amazon and Mississippi are doing now, and this especially on the sides toward the present continental plateaus, though the greater part must have been derived from the wide tracts of Laurentian land within the Arctic Circle or near to it. It is further obvious that the ordinary reasoning respecting the necessity of continental areas in the present ocean basins would actually oblige us to suppose that the whole of the oceans and continents had repeatedly changed places. This consideration opposes enormous physical difficulties to any theory of alternations of the oceanic and continental areas, except locally at their margins. I would, however, refer you for a more full discussion of these points to the address to be delivered to-morrow by the president of the Geological Section. But the permanence of the Atlantic depression does

not exclude the idea of successive submergences of the continental plateaus and marginal slopes, alternating with periods of elevation, when the ocean retreated from the continents and contracted its limits.

In this respect the Atlantic of to-day is much smaller than it was in those times when it spread widely over the continental plains and slopes, and much larger than it has been in times of continental elevation. This leads us to the further consideration that, while the ocean beds have been sinking, other areas have been better supported, and constitute the continental plateaus; and that it has been at or near the junctions of these sinking and raising areas that the thickest deposits of detritus, the most extensive foldings, and the greatest ejections of volcanic matter have occurred. There has thus been a permanence of the position of the continents and oceans throughout geological time, but with many oscillations of these areas, producing submergences and emergences of the land. In this way we can reconcile the vast vicissitudes of the continental areas in different geological periods with that continuity of development from north or south, and from the interiors to the margins, which is so marked a feature. We have for this reason to formulate another apparent geological paradox, namely, that while in one sense the continental and oceanic areas are permanent, in another they have been in continual movement. Nor does this view exclude extension of the continental borders or of chains of islands beyond their present limits at certain periods; and, indeed, the general principle already stated, that subsidence of the ocean bed has produced elevation of the land, implies in earlier periods a shallower ocean and many possibilities as to volcanic islands, and low continental margins creeping out into the sea; while it is also to be noted that there are, as already stated, bordering shelves, constituting shallows in the ocean, which at certain periods have emerged as land.

We are thus compelled to believe in the contemporaneous existence in all geological periods, except perhaps the earliest of them, of three distinct conditions of areas on the surface of the earth: (1) Oceanic areas of deep sea, which always continued to occupy in whole or in part the bed of the present ocean. (2) Continental plateaus and marginal shelves, existing as low flats or higher tablelands liable to periodical submergence and emergence. (3) Lines of plication and folding, more especially along the borders of the oceans, forming elevated portions of land, rarely altogether submerged, and constantly affording the material of sedimentary accumulations, while they were also the seats of powerful volcanic ejections. In the successive geological periods the continental plateaus, when submerged, owing to their vast extent of warm and shallow sea, have been the great theaters of the development of marine life and of the deposition of organic limestones, and when elevated they have furnished the abodes of the noblest land faunas and floras. The mountain belts, especially in the north, have been the refuge and stronghold of land life in periods of submergence, and the deep ocean basins have been the perennial abodes of pelagic and abyssal creatures, and the refuge of multitudes of other marine animals and plants in times of continental elevation. These general facts are full of importance with reference to the question of the succession of formations and of life in the geological history of the earth.

THE HISTORY OF THE ATLANTIC.

So much time has been occupied with these general views that it would be impossible to trace the history of the Atlantic in detail through the ages of the Palæozoic, Mesozoic, and Tertiary. We may, however, shortly glance at the changes of the three kinds of surface already referred to. The bed of the ocean seems to have remained on the whole abyssal, but there were probably periods when those shallow reaches of the Atlantic which stretch across its most northern portion, and partly separate it from the Arctic basin, presented connecting coasts or continuous chains of islands sufficient to permit animals and plants to pass over. At certain periods also there were not unlikely groups of volcanic islands like the Azores, in the temperate and tropical Atlantic. More especially might this be the case in that early time when it was more like the present Pacific; and the line of the great volcanic belt of the Mediterranean, the mid-Atlantic banks, the Azores, and the West India Islands point to the possibility of such partial connections. These were stepping stones, so to speak, over which land organisms might cross, and some of these may be connected with the fabulous or prehistoric Atlantic. In the Cambrian and Ordovician periods the distinctions, already referred to, into continental plateaus, mountain ridges, and ocean depths were first developed, and we find already great masses of sediment accumulating on the seaward sides of the old Laurentian ridges, and internal deposits thinning away from these ridges over the submerged continental areas, and presenting very dissimilar conditions of sedimentation. It would seem also that, as Hicks has argued for Europe, and Logan and Hall for America, this Cambrian age was one of slow subsidence of the land previously elevated, accompanied with or caused by thick deposits of detritus along the borders of the subsiding land, which was probably covered with the decomposing rock arising from long ages of subaerial waste. In the coal-formation age, its characteristic swampy flats stretched in some places far into the shallower parts of the ocean. In the Jurassic, the American continent probably extended further to the sea than at present. In the Wealden age there was much land to the west and north of Great Britain, and Professor Bonney has directed attention to the evidence of the existence of this land as far back as the Trias, while Mr. Starkie Gardiner has insisted on connecting links to the southward as evidenced by fossil plants. So late as the Post-Glacial, or early human period, large tracts now submerged formed portions of the continents. On the other hand, the internal plains of America and Europe were often submerged. Such submergences are indicated by the great limestones of the Palæozoic, by the chalk and its representative beds in the Cretaceous, by the Nummulitic formation in the Eocene, and lastly by the great Pleistocene submergence, one of the most remarkable of all, one in which nearly the whole northern hemisphere participated, and which was probably separated from the present time by only a few thousands of years. These submergences and elevations were not always alike on the two sides of the Atlantic. The Salina period of the Silurian, for example, and the Jurassic, show continental elevation in America not shared by Europe. The great subsidences of the Cretaceous and the Eocene were proportionally deeper and wider on the eastern continent, and this and the direction of the land being from north to south cause more ancient forms of life to survive in America.

These elevations and submergences of the plateaus alternated with the periods of mountain-making plication, which was going on at intervals at the close of the Eozoic, at the beginning of the Cambrian, at the close of the Siluro-Cambrian, in the Permian, and in Europe and Western America in the Tertiary. The series of changes, however, affecting all these areas was of a highly complex character, and embraces the whole physical history of the geological ages. We may note here that the unconformities caused by these movements and by subsequent denudation constitute what Le Conte has called "lost intervals," one of the most important of which is supposed to have occurred at the end of the Eozoic.

It is to be observed, however, that as every such movement is followed by gradual subsidence, the seeming loss is caused merely by the overlapping of the successive beds deposited. We may also note a fact which I have long ago insisted on, the regular pulsations of the continental areas, giving us alternations in each great system of formations of deep-sea and shallow-water beds, so that the successive groups of formations may be divided into triplets of shallow water, deep water, and shallow water strata, alternating in each period. But I must here call your attention to still another geological paradox, namely, that the deep sea, which is so great a barrier to the passage of the shallow water animals, seems, under certain conditions, to afford facilities for the transmission of land animals and plants.

The connections established by the observations of the Challenger, and so well expounded by Wallace and Hemsley, between the floras of oceanic islands and the continents establish this conclusively. Thus the Bermudas, altogether recent islands, have been stocked, by the agency chiefly of the ocean currents and of birds, with nearly 150 species of continental plants, and the facts collected by Hemsley as to the present facilities of transmission, along with the evidence afforded by older oceanic islands which have been receiving animal and vegetable colonists for longer periods, go far to show that, time being given, the sea actually affords facilities for the migrations of the inhabitants of the land greater than those of continuous continents.

THE CLIMATE OF THE ATLANTIC.

We can scarcely doubt that the close connection of the Atlantic and Arctic oceans is one factor in those remarkable vicissitudes of climate experienced by the former, and in which the Pacific area has also shared in connection with the Antarctic Sea. No geological facts are indeed at first sight more strange and inexplicable than the changes of climate in the Atlantic area, even in comparatively modern periods. We know that in the early Tertiary perpetual summer reigned as far north as the middle of Greenland, and that in the Pleistocene the Arctic cold advanced, until an almost perennial winter prevailed half way to the equator. It is no wonder that nearly every cause available in the heavens and the earth has been invoked to account for these astounding facts. It will, I hope, meet with the approval of your veteran glaciologist, Dr. Crosskey, if, neglecting most of these theoretical views, I venture to invite your attention in connection with this question chiefly to the old Lyellian doctrine of the modification of climate by geographical changes. Let us, at least, consider how much these are able to account for.

The ocean is a great equalizer of extremes of temperature. It does this by its great capacity for heat and by its cooling and heating power when passing from the solid into the liquid and gaseous states, and the reverse. It also acts by its mobility, its currents serving to convey heat to greater distances or to cool the air by the movement of cold, icy waters. The land, on the other hand, cools or warms rapidly, and can transmit its influence to a distance only by the winds, and the influence so transmitted is rather in the nature of a disturbing than an equalizing cause. It follows that any change in the distribution of land and water must affect climate, more especially if it changes the character or course of the ocean currents. At the present time the North Atlantic presents some very peculiar and in some respects exceptional features, which are most instructive with reference to its past history.

The great internal plateau of the American continent is now dry land; the passage across Central America between the Atlantic and Pacific is blocked; the Atlantic opens very widely to the north; the high mass of Greenland towers in its northern part. The effects are that the great equatorial current running across from Africa, and embayed in the Gulf of Mexico, is thrown northward and eastward in the Gulf Stream, acting as a hot-water apparatus to heat up to an exceptional degree the western coast of Europe. On the other hand, the cold Arctic current from the polar seas is thrown to the westward, and runs down from Greenland past the American shore. The pilot chart for June of this year shows vast fields of drift ice on the western side of the Atlantic as far south as the latitude of 40°. So far, therefore, the glacial age in that part of the Atlantic still extends; this at a time when, on the eastern side of the ocean, the culture of cereals reaches in Norway beyond the Arctic circle.

Let us inquire into some of the details of these phenomena. The warm water thrown into the North Atlantic not only increases the temperature of its whole waters, but gives an exceptionally mild climate to Western Europe. Still the countervailing influence of the Arctic currents and the Greenland ice is sufficient to permit icebergs which creep down to the mouth of the Strait of Belle Isle, in the latitude of the south of England, to remain unmelted till the snows of a succeeding winter fall upon them. Now let us suppose that a subsidence of land in tropical America were to allow the equatorial current to pass through into the Pacific. The effect would at once be to reduce the temperature of Norway and Britain to that of Greenland and Labrador at present, while the latter countries would themselves become colder. The northern ice, drifting down into the Atlantic, would not, as now, be melted rapidly by the warm water which it meets in the Gulf Stream. Much larger quantities of it would remain undissolved in summer, and thus an accumulation of permanent ice would take place, along the American coast at first, but probably at length even on the European side. This would still further chill the atmosphere, glaciers would be established on all the mountains of temperate Europe and America, the summer would be kept cold by melting ice and snow, and at length all Eastern America and Europe might become uninhabitable, except by Arctic animals and plants, as far south as perhaps 40° of north latitude. This would be simply a return of the Glacial age. I have assumed only one geographical change; but other and more complete changes of subsidence and elevation might take place with effects on climate still more decisive; more especially would this be the case if there were a considerable submergence of the land in temperate latitudes. We may suppose an opposite case. The high plateau of Greenland might subside or be reduced in height, and the openings of Baffin's Bay and the North Atlantic might be closed. At the same time the interior plain of America might be depressed so that, as we know to have been the case in the Cretaceous period, the warm waters of the Mexican Gulf would circulate as far north as the basins of the present great American lakes. In these circumstances there would be an immense diminution of the sources of floating ice, and a correspondingly vast increase in the surface of warm water. The effect would be to enable a temperate flora to subsist in Greenland, and to bring all the present temperate regions of Europe and America into a condition of sub-tropical verdure.

THE GLACIAL PERIOD.

We have in America ancient periods of cold as well as warmth. I have elsewhere referred to the bowlder conglomerates of the Huronian, of the Cambrian and Ordovician, of the Millstone-grit period of the Carboniferous, and of the early Permian; but would not venture to affirm that either of these periods was comparable in its cold with the later Glacial age, still less with that imaginary age of continental glaciation assumed by certain of the more extreme theorists. These ancient conglomerates were probably produced by floating ice, and this at periods when in areas not very remote temperate floras and faunas could flourish. The glacial periods of our old continent occurred in times when the surface of the submerged land was opened up to the northern currents, drifting over it mud, and sand, and stones, and rendering nugatory, in so far, at least, as the bottom of the sea was concerned, the effects of the superficial warm streams. Some of these beds are also peculiar to the eastern margin of the continent, and indicate ice-drift along the Atlantic coast in the same manner as at present, while conditions of greater warmth existed in the interior. Even in the more recent Glacial age, while the mountains were covered with snow and the lowlands submerged under a sea laden with ice, there were interior tracts in somewhat high latitudes of America in which hardy forest trees and herbaceous plants flourished abundantly; and these were by no means exceptional "interglacial" periods. Thus we can show that while from the remote Huronian period to the Tertiary the American land occupied the same position as at present, and while its changes were merely changes of relative level as compared with the sea, these have so influenced the ocean currents as to cause great vicissitudes of climate. Without entering on any detailed discussion of that last and greatest Glacial period which is best known to us, and is more immediately connected with the early history of man and the modern animals, it may be proper to make a few general statements bearing on the relative importance of sea-borne and land ice in producing those remarkable phenomena attributable to ice action in this period.

In considering this question it must be borne in mind that the greater masses of floating ice are produced at the seaward extremities of land glaciers, and that the heavy field ice of the Arctic regions is not so much a result of the direct freezing of the surface of the sea as of the accumulation of snow precipitated on the frozen surface. In reasoning on the extent of ice action, and especially of glaciers in the Pleistocene age, it is necessary to keep this fully in view. Now in the formation of glaciers at present—and it would seem almost in any conceivable former state of the earth—it is necessary that extensive evaporation should conspire with great condensation of water in the solid form. Such conditions exist in mountainous regions sufficiently near to the sea, as in Greenland, Norway, the Alps, and the Himalayas; but they do not exist in low Arctic lands like Siberia or Grinnell Land nor in the inland mountains. It follows that land glaciation has narrow limits, and that we cannot assume the possibility of great confluent and continental glaciers covering the interior of wide tracts of land. No imaginable increase of cold could render this possible, inasmuch as there could not be a sufficient influx of vapor to produce the necessary condensation; and the greater the cold, the less would be the evaporation. On the other hand, any increase of heat would be felt more rapidly in the thawing and evaporation of land ice and snow than on the surface of the sea. Applying these very simple geographical truths to the North Atlantic continents, it is easy to see that no amount of refrigeration could produce a continental glacier, because there could not be sufficient evaporation and precipitation to afford the necessary snow in the interior. The case of Greenland is often referred to, but this is the case of a high mass of cold land with sea, mostly open, on both sides of it, giving, therefore, the conditions most favorable to precipitation of snow. If Greenland were less elevated, or if there were dry plains around it, the case would be quite different, as Nares has well shown by his observations on the summer verdure of Grinnell Land, which, in the immediate vicinity of North Greenland, presents very different conditions as to glaciation and climate. If the plains were submerged, and the Arctic currents allowed free access to the interior of the continent of America, it is conceivable that the mountainous regions remaining out of water would be covered with snow and ice, and there is the best evidence that this actually occurred in the Glacial period; but with the plains out of water this would be impossible. We see evidence of this at the present day in the fact that in unusual cold winters the great precipitation of snow takes place south of Canada, leaving the north comparatively bare, while as the temperature

becomes milder the area of snow deposit moves further to the north. Thus a greater extension of the Atlantic, and especially of its cold, ice-laden Arctic currents, becomes the most potent cause of a glacial age. I have long maintained these conclusions on general geographical grounds, as well as on the evidence afforded by the Pleistocene deposits of Canada; and in an address the theme of which is the ocean I may be excused for continuing to regard the supposed terminal moraines of great continental glaciers as nothing but the southern limit of the ice drift of a period of submergence. In such a period the southern margin of an ice-laden sea, where its floe ice and bergs grounded, or where its ice was rapidly melted by warmer water, and where consequently its burden of bowlders and other debris was deposited, would necessarily present the aspect of a moraine, which by the long continuance of such conditions might assume gigantic dimensions. Let it be observed, however, that I fully admit the evidence of the great extension of local glaciers in the Pleistocene age, and especially in the times of partial submergence of the land. I am quite aware that it has been held by many able American geologists that in North America a continental glacier extended in temperate latitudes from sea to sea, or at least from the Atlantic to the Rocky Mountains, and that this glacier must, in many places, have exceeded a mile in thickness. The reasons above stated appear, however, sufficient to compel us to seek for some other explanation of the observed facts, however difficult this may at first sight appear.

TRANSMISSION OF ANIMAL LIFE ACROSS THE OCEAN.

With reference to the transmission of living beings across the Atlantic, we have before us the remarkable fact that from the Cambrian age onward there were on the two sides of the ocean many species of invertebrate animals which were either identical or so closely allied as to be possibly varietal forms. In like manner the early plants of the Upper Silurian, Devonian, and Carboniferous present many identical species; but this identity becomes less marked in the vegetation of the more modern times. In so far as plants are concerned, it is to be observed that the early forests were largely composed of cryptogamous plants, and the spores of these in modern times have proved capable of transmission for great distances. In considering this we cannot fail to conclude that the union of simple cryptogamous fructification with arboreal stems of high complexity, so well illustrated by Dr. Williamson, had a direct relation to the necessity for a rapid and wide distribution of these ancient trees. It seems also certain that some spores, as, for example, those of the Rhizocarps, a type of vegetation abundant in the Palæozoic, and certain kinds of seeds, as those named *Ætheotesta* and *Pachytheca*, were fitted for flotation.

Further, the periods of Arctic warmth permitted the passage around the northern belt of many temperate species of plants, just as now happens with the Arctic flora; and when these were dispersed by colder periods they marched southward along both sides of the sea on the mountain chains. The same remark applies to northern forms of marine invertebrates, which are much more widely distributed in longitude than those further south. The late Mr. Gwyn Jeffreys, in one of his latest communications to this Association, stated that 54 per cent. of the shallow water mollusks of New England and Canada are also European, and of the deep sea forms 30 out of 35; these last, of course, enjoying greater facilities for migration than those which have to travel slowly along the shallows of the coasts in order to cross the ocean and settle themselves on both sides. Many of these animals, like the common mussel and sand clam, are old settlers which came over in the Pleistocene period, or even earlier. Others, like the common periwinkle, seem to have been slowly extending themselves in modern times, perhaps even by the agency of man. The other immigrants may possibly have taken advantage of lines of coast now submerged, or of warm periods, when they could creep around by the Arctic shores. Mr. Herbert Carpenter and other naturalists employed on the Challenger collections have made similar statements respecting other marine invertebrates, as, for instance, the Echinoderms, of which the deep sea crinoids present many common species, and my own collections prove that many of the shallow water forms are common. Dall and Whiteaves have shown that some mollusks and Echinoderms are common even to the Atlantic and Pacific coasts of North America; a remarkable fact, testifying at once to the fixity of these species and to the manner in which they have been able to take advantage of geological changes. Some of the species of whelks common to the Gulf of St. Lawrence and Pacific are animals which have no special locomotive powers even when young, but they are northern forms not proceeding far south, so that they may have passed through the Arctic seas. In this connection it is well to remark that many species of animals have powers of locomotion in youth which they lose when adult, and that others may have special means of transit. I once found at Gaspe a specimen of the Pacific species of Coronula, or whale barnacle, the C. reginæ of Darwin, attached to a whale taken in the Gulf of St. Lawrence, and which had probably succeeded in making that passage around the north of America which so many navigators have essayed in vain.

It is to be remarked here that while many plants and marine invertebrates are common to the two sides of the Atlantic, it is different with land animals, and especially vetebrates. I do not know that any fossil insects or land snails or millipedes of Europe and America are specifically identical, and of the numerous species of batrachians of the Carboniferous and reptiles of the Mesozoic all seem to be distinct on the two sides. The same appears to be the case with the Tertiary mammals, until in the later stages of that great period we find such genera as the horse, the camel, and the elephant appearing on two sides of the Atlantic; but even the species seem different, except in the case of a few northern forms. Some of the longer lived mollusks of the Atlantic furnish suggestions which remarkably illustrate the biological aspect of these questions. Our familiar friend the oyster is one of these. The first known oysters appear in the Carboniferous in Belgium and in the United States of America. In the Carboniferous and Permian they are few and small, and they do not culminate till the Cretaceous, in which there are no less than 91 so-called species in America alone; but some of the largest known species are found in the Eocene.

The oyster, though an inhabitant of shallow water, and very limitedly locomotive when young, has survived all the changes since the Carboniferous age, and has spread itself over the whole northern hemisphere. I have collected fossil oysters in the Cretaceous clays of the coulees of Western Canada, in the lias shales of England, in the Eocene and Cretaceous beds of the Alps, of Egypt, of the Red Sea, of Judea, and the heights of Lebanon. Everywhere and in all formations they present forms which are so variable and yet so similar that one might suppose all the so-called species to be mere varieties. Did the oyster originate separately on the two sides of the Atlantic, or did it cross over so promptly that its appearance seems to be identical on the two sides? Are all the oysters of a common ancestry, or did the causes, whatever they were, which introduced the oyster in the Carboniferous act over again in the late periods? Who can tell? This is one of the cases where causation and development—the two scientific factors which constitute the basis of what is vaguely called evolution—cannot easily be isolated. I would recommend to those biologists who discuss these questions to addict themselves to the oyster. This familiar mollusk has successfully pursued its course and has overcome all its enemies, from the flat toothed selachians of the Carboniferous to the oyster dredgers of the present day, has varied almost indefinitely, and yet has continued to be an oyster, unless, indeed, it may at certain portions of its career have temporarily assumed the disguse of a Gryphæa or an Exogyra. The history of such an animal deserves to be traced with care, and much curious information respecting it will be found in the report which I have cited. But in these respects the oyster is merely an example of many forms.

Similar considerations apply to all those Pliocene and Pleistocene mollusks which are found in the raised sea bottoms of Norway and Scotland, on the top of Moel Tryfaen in Wales, and at similar great heights on the hills of America, many of which can be traced back to early Tertiary times, and can be found to have extended themselves over all the seas of the northern hemisphere. They apply in like manner to the ferns, the conifers, and the angiosperms, many of which we can now follow without even specific change to the Eocene and Cretaceous. They all show that the forms of living things are more stable than the lands and seas in which they live. If we were to adopt some of the modern ideas of evolution, we might cut the Gordian knot by supposing that, as like causes can produce like effects, these types of life have originated more than once in geological time, and need not be genetically connected with each other. But while evolutionists repudiate such an application of their doctrine, however natural and rational, it would seem that nature still more strongly repudiates it, and will not allow us to assume more than one origin for one species. Thus the great question of geographical distribution remains in all its force, and, by still another of our geological paradoxes, mountains become ephemeral things in comparison with the delicate herbage which covers them, and seas are in their present extent but of yesterday when compared with the minute and feeble organisms that creep on their sands or swim in their waters.

DESTINY OF THE ATLANTIC.

The question remains, Has the Atlantic achieved its destiny and finished its course, or are there other changes in store for it in the future? The earth's crust is now thicker and stronger than ever before, and its great ribs of crushed and folded rock are more firm and rigid than in any previous period. The stupendous volcanic phenomena manifested in Mesozoic and early Tertiary times along the borders of the Atlantic have apparently died out. These facts are in so far guarantees of permanence.

On the other hand, it is known that movements of elevation along with local depression are in progress in the Arctic regions, and a great weight of new sediment is being deposited along the borders of the Atlantic, especially on its western side, and this is not improbably connected with the earthquake shocks and slight movements of depression which have occurred in North America. It is possible that these slow and secular movements may go on uninterruptedly until considerable changes are produced; but it is quite as likely that they may be retarded or reversed. It is possible, on the other hand, that after the long period of quiescence which has elapsed there may be a new settlement of the ocean bed, accompanied with foldings of the crust, especially on the western side of the Atlantic, and possibly with renewed volcanic activity on its eastern margin. In either case a long time relatively to our limited human chronology may intervene before the occurrence of any marked change. On the whole, the experience of the past would lead us to expect movements and eruptive discharges in the Pacific rather than in the Atlantic area. It is therefore not unlikely that the Atlantic may remain undisturbed, unless secondarily and indirectly, until after the Pacific area shall have attained to a greater degree of quiescence than at present. But this subject is one too much involved in uncertainty to warrant us in following it further.

In the mean time the Atlantic is to us a practically permanent ocean, varying only in its tides, its currents, and its winds, which science has already reduced to definite laws, so that we can use, if we cannot regulate, them. It is ours to take advantage of this precious time of quietude, and to extend the blessings of science and of our Christian civilization from shore to shore, until there shall be no more sea, not in the sense of that final drying up of old ocean to which some physicists look forward, but in the higher sense of its ceasing to be the emblem of unrest and disturbance, and the cause of isolation.

I must now close this address with a short statement of the general objects which I have had in view in directing your attention to the geological development of the Atlantic. We cannot, I think, consider the topics to which I have referred without perceiving that the history of ocean and continent is an example of progressive design, quite as much as that of living beings. Nor can we fail to see that, while in some important directions we have penetrated the great secret of nature, in reference to the general plan and structure of the earth and its waters, and the changes through which they have passed, we have still very much to learn, and perhaps quite as much to unlearn, and that the future holds out to us and to our successors higher, grander, and clearer conceptions than those to which we have yet attained. The vastness and the might of ocean, and the manner in which it cherishes the feeblest and most fragile beings, alike speak to us of Him who holds it in the hollow of His hand, and gave to it of old its boundaries and its laws; but its teaching ascends to a higher tone when we consider its origin and history, and the manner in which it has been made to build up continents and mountain chains, and at the same time to nourish and sustain the teeming life of sea and land.

THE DIRECTIONS OF DEVELOPMENT THE TRUE INDICATIONS OF CHARACTER.

By J. W. REDFIELD, M.D.

THE life forces, of whatever class, and by whatever name designated, must be regarded as interior to the forms in which they are manifested, and as acting outward in the directions of their various objects of desire. Let us begin our illustrations of the principle with one of the most obvious. The appetites, the cravings of animal life for those substances which are necessary to its organic sustentation, evidently act along the lines of contact between the upper and lower jaws, their objects being always ahead of them, in the direction of smell and taste. The stronger the appetite, the stronger its progressive action along the rim of the jaw, depositing the materials of construction in its track, and making the extent of development in exact proportion to the vital force. For example: The herbivora demand much more food for the support of their corporeal life than the carnivora, chiefly because the vegetable food they make use of is much less nutritious than animal food; and therefore the jaws of the herbivora, as a general rule, are much longer than those of the carnivora. Of the herb eaters, the ruminants less persistently seek their food than the non-ruminants, for the simple reason that they are better nourished by spending a good deal of time in the quiet enjoyment of chewing it over again; and hence their jaws are broader and not so long, as we see by comparison between the cow and the horse. Of the flesh eaters, those most noisily and hastily eager for their food, which is therefore most hasty to get beyond their reach, have very long jaws, signifying the progress of appetite in the direction of pursuit, while those that steal slowly and silently upon their prey, till able to seize upon it at a single bound, to play and toy with it by way of preparation for the more sober enjoyment of eating it, have much shorter jaws, signifying the moderation of the appetite that can act in such a deliberate manner. This familiar difference between the impetuous dog and the mousing cat, in which the one hunts chiefly in packs and the other always alone, is like that between the canine and feline species in general.

The illustration of our principle in the length of jaws is as various in animals under domestication as the will or caprice of the breeder. He can either shorten or lengthen their jaws, and therewith, by the laws of harmonious relationship, change all the other proportions of their bodies, in accordance with either his fancies or whatever utilitarian objects he may have in view. By placing an abundance of the food they like best close before their noses, man has changed the long jaws of the wild boar and the scavenger cur to the short jaws of the Suffolk and the pug; and by setting them on the scent of food far away, the one by design and the other by neglect, he has developed the long nosed hound and the still more long nosed pig of Florida and San Domingo. In "Animals and Plants under Domestication" (p. 115), Darwin says of the "niata breed" of cattle on the Plata: "The exposed incisor teeth, the short head, and upturned nostrils, give these cattle the most ludicrous, self-confident air of defiance;" and he appears to give the clew to its explanation in this: "When the pasture is tolerably long, these cattle feed as well as common cattle, with their tongue and palate; but during the great droughts, when so many animals perish on the Pampas, the niata breed lies under a great disadvantage, and would, if not attended to, become extinct." It is evident, therefore, that "the niata modification" could not have "arisen in a state of nature," but must have arisen from the confident habit of looking up to hospitable masters for subsistence in defiance of times of scarcity, during hundreds of years in a state of domestication.

The jaws not only go out toward the food demanded by the appetite for the support of the body, in the degree of the effort required for its attainment, but they constitute the instrument for seizing and holding it, preparatory to its reception by the stomach. They must therefore present, in some way, indications of the various *kinds* of appetite connected with the sense of *taste*, which is placed just where the tongue comes in contact with the crushed and partially dissolved food, to test the degree of its adaptation to the animal economy by which it is about to be appropriated. When the food is in possession it is subject to deliberate, critical examination, by the various *kinds* of appetite; and these, acting in the direction of it, act upward and downward, and in various minor directions, giving the positions and various forms of the teeth. In the ruminants, the lower and only incisors are projecting and almost horizontal, because of the direction of the food to be obtained; but fairly within the mouth, the incisive lamina are placed in the upper jaw, as well as in the lower, and have deliberately folded themselves into the forms of the various grinders, so that their action in the direction of the food to be comminuted between them, as between the upper and nether millstones, is not horizontal, like the action of the front incisors, but perpendicular. In the carnivora, the food being of the kind to be seized and torn, rather than cropped and ground, the teeth are not only vertical, but hooked and conical, either singly, as in various fishes and reptiles, which make no delay for the appreciation of food by taste, or else in complex combination, as in the "double teeth" of the cat and dog, which have tongues endowed with a good degree of sensibility to taste as well as to touch.

The absence of teeth in birds is accompanied, in the great majority of instances, by an incasement of the tip of the tongue in a horny sheath; and the food, we know, makes no delay in the mouth, but is bolted whole, to be ground in the gizzard. In birds, there-

fore, there is generally an excess of appetite over taste, or over that which divides appetite into its varieties, distinguishing pleasurably between one kind and another. The consequence of this non-restraint upon the rapacity of appetite is excessive consumption, and therewith more excessive examples of long jaws in birds than in any other animals, with the exception of the other edentata, such as the pipe fishes and the ant eaters. The heron and stork stretch out their long bills and necks, and rush like spears from clime to clime, in the direction of better feeding grounds than those which they have impoverished and forsaken. Between the periods of their migration, they spend the greater part of their time in swallowing, rather than in eating, and the consequence of such enormous consumption of food is excessive consumption of body, the processes of digestion and assimilation in them being almost as disproportioned to appetite as those of mastication and taste. The greater the waste of food in inappreciative swallowing, the greater the waste of flesh in the consumer. This is really, to a very great degree, an explanation of the disease called "consumption." It is Pharaoh's lean kine devouring his fat kine, and continuing as ill-favored as ever. But as the sense of taste lies in the tongue, we may believe that an animal in which the tongue is the instrument of prehension, as it is in the cow, in the giraffe, in the ant eater, in the chameleon, in the woodpecker, and in the humming-bird, may have a very long jaw as a sort of sheath for its protection, indicating very great appetite in subserviency to an excessive degree and delicacy of the sense of taste. The sprightly humming-bird, with the exceeding appetite indicated in his very long bill, darts with the straightness and swiftness of a feathered ray in the direction of the food he is most eager to obtain; but we may be sure that the appreciation of it resident in his very long tongue, converting it into the very nectar and ambrosia of the gods, is sufficient to overcome any such consumption as is expressed in the cadaverous body and moping melancholy of the heron and crane.

These most remarkable indications of appetite in the directions of development in the lower animals bring us to the observation of the less remarkable, but more important, indications of the same faculty in man. Appetite being one of the earliest and most necessary of the life forces, without which the body could not be supplied with the materials necessary to its constant revival and reorganization, we may naturally expect to find the indications of it excessive in the lowest type of humanity, and comparatively deficient in the highest. It forms, in fact, the base line of the famous "facial angle" of Camper, by which he estimated the relative positions of the various members of the human family in the scale of development. The principle that the life forces, superior and inferior, are developed in the directions of their objects will furnish the means by which that same "facial angle," with proper explanations, may be as valuable in comparative physiognomy as it was ever claimed to be. At present we will only concern ourselves with the basis of it, the comparative degrees of appetite as indicated in the comparative lengths of the upper and lower jaws in different individuals. The prognathous jaws of the Guinea negro are clearly an excessive development of the appetites in the direction of their objects, and show that in the pursuit of them he is far ahead of most other people. His posture is that of the forager, inclining strongly in the direction of the jaws. In both attitude and prognathism he is the very reverse of the ideal represented in the Apollo Belvedere. There is much the same difference between the peasant and the prince. Perfection lies in the medium between the two extremes. The facial angle of the Greek divinities transcends human nature, as much because the jaws are too retreating as because the features above them are too prominent. In human beings, as well as in animals, there is such a thing as not enough length of jaws, as well as too much, for good taste. Appetite and taste must be in due proportion to each other, and neither of them deficient, in the perfection attained by nature through the medium of art. The carrier pigeon, by the use to which it has been bred, has developed a length of jaw exceeding that of the parent type (*Columba livia*), and stands with a more forward inclination, like a messenger; while the tumbler, by being bred to the reverse action, that of tumbling over and over backward, has acquired abnormally short jaws, and stands in a proud, strutting attitude, like a prince. The carrier pigeon, by enforced distance from its food and home, has been changed from the parent type in the direction of the more useful, and is therefore a normal and highly vigorous production, though less symmetrical than its great ancestor; but the short-billed pouter and tumbler are pampered, "fancy breeds," and therewith abnormal and sickly, like that artificial, unnatural, useless class of society called "fancy men."

Vegetables are lower than animals, and hence the appetites for vegetable food are indicated chiefly in the lower jaw, and those for animal food chiefly in the upper. Cannibals and the sort of savages that live by hunting and fishing are like the carnivora in being more developed in the upper jaw than in the lower, while those that live chiefly on roots and herbs are like the herbivora in being more developed in the lower jaw than in the upper. In the naturally vegetarian class, there is even a like difference between infants and adults, the first food of all the mammalia being milk. Darwin says that the calf shows a rudimentary promise of upper incisors, but fails of its fulfillment. The lower incisors are developed at the expense of the upper, to such a degree as to utterly annihilate them, simply because the herbivorous appetites are so extravagantly developed at the expense of the carnivorous. The apparent conversion of the carnivorous into the herbivorous appetites proceeds to such a degree that the rudimentary conical form of the teeth becomes completely lost in the development of the incisive. It is in reality not a conversion, but another case of the survival of the fittest. The excessive infancy with which the carnivora are born, in contrast with the excessive want of it in the new-born herbivora, explains, more than anything else, the contrast between them in the character of their appetites. In view of the fact that in the pre-natal stage of its existence every mammal is a bloodthirsty parasite, it is safe to say that but for so little of this parasitical character that he "ran alone" from his very birth, the bullock might have learned to eat flesh like the lion, and that but for so much of it that it lasts him through life, the lion might at last come to "eat straw like the ox." Only in the animal basis of the human, in which infancy and independence are the equals of each other, can this allegory of the good time coming be realized. The two characters, so opposite and yet so similar, are happily united in the British lion, John Bull, the fountain-head of Anglo-Saxondom.

CARL WILHELM SCHEELE.

J. B. Dumas, in his biography of Scheele, speaks thus of three founders of modern chemistry—Lavoisier, Priestley, and Scheele: "The one, a man of the world, rich, surrounded by the élite of scientific men, himself their leader, rises above all contemporaneous glory. The other, an ecclesiastic, a fierce theologian, a politician by position, without fortune, but sustained by a few friends of learning, casts a passing ray, but a ray that still dazzles us. The last (Scheele), a pharmaceutical student, poor and modest, unknown to the world, scarcely knowing himself, inferior to the first, but far superior to the second, conquering nature by the power of patience and genius, drags its secrets from it and wins for himself eternal fame." The last of these chemists was born in Stralsund, Sweden, on December 9, 1742. He died in Koeping, Sweden, May 21, 1786, one hundred years ago. His centennial has just been celebrated in his native country. In the year of Scheele's death Chevreul was born, thus linking the present with the past and recalling to the recollection the same relation existing between Galileo and Newton. The account of his life has already been given in these columns.* The following account of his life's work is largely taken from Prof. Cleve's monograph, published on the occasion of the centennial in the *Revue Scientifique*.

CARL WILHELM SCHEELE.
(*Swedish Familjejournal.*)

He was, after a course of studies in the gymnasium at Stralsund, apprenticed at the age of fourteen years to a pharmacist, Bauch of Gothembourg. He began reading and experimenting at once in chemistry, encouraged by a friend, Grünberger. He read the early chemical works, and from this period to the day of his death the work of his life may be told in these three words—pharmacy, reading, and chemical experiments.

* See Scientific American Supplement, No. 340, p. 5425.

Six years of apprenticeship and two years of freedom was the extent of his sojourn in Gothembourg. Then followed three years in Malmoe with the pharmacist Kjellström, two years in Stockholm in the "Korpen" pharmacy, five years in Upsal with Lokk, and finally eleven years in charge of the pharmacy in Koeping, where he died.

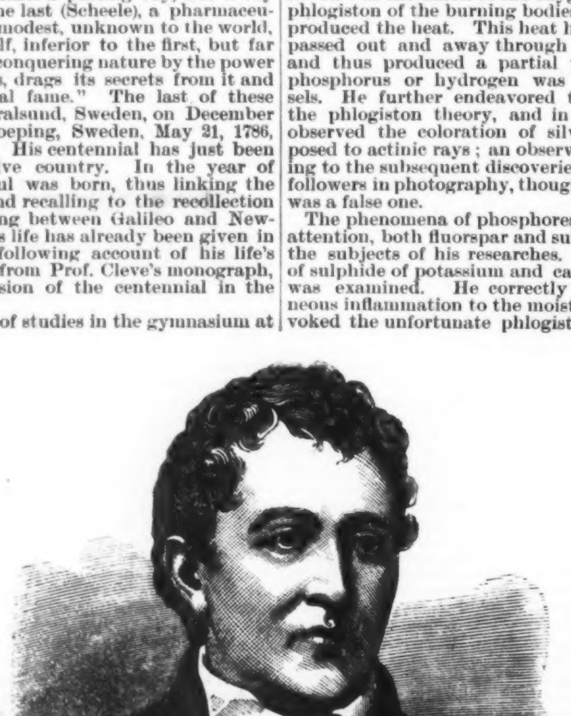
He was always experimenting and discovering new substances during these years, so that he ranks to-day as the discoverer of more chemical compounds than any other chemist. Fettered by his belief in the old theory of phlogiston, it is curious to see how nearly he reduced his conception of it to that of hydrogen.

On the 1st of August, 1774, Priestley made oxygen by heating oxide of mercury. A year later in Paris he communicated his discovery to Lavoisier. In 1775, Scheele had terminated a series of researches on fire and air, and his book on the subject was finished in October, 1776, though it only appeared a couple of years later. He discovered oxygen, probably a little later than did Priestley. The latter says, "Mr. Scheele's discovery was certainly independent of mine, though, I believe, not made quite as early." He made it in various ways; from pyrolusite heated with sulphuric acid, from oxide of mercury, and from nitric acid. He found that it maintained combustion with great energy, and was more soluble in water than nitrogen. He showed that it was indispensable for life, animal and vegetable. He breathed repeatedly a given volume of air from a bladder, and found that carbonic acid gas was thus formed. He inclosed flies in a flask containing a little honey on a slip of paper. In two or three days the flies died, without change in the volume of air, but with production of a quantity of carbonic acid gas. He tried the same experiment with peas, which, in less degree still, acted in a similar manner, ceasing to grow after fifteen days. He then, by treating the air with milk of lime, removed the carbonic acid gas, and then introduced a quantity of oxygen, whereupon their growth recommenced. He also tried to make peas grow in pure oxygen, but could not succeed.

In his experiments with pyrolusite, Scheele had found in this mineral a body that absorbed energetically the phlogiston of combustible bodies (in modern language, it was an oxidizer). He found also that binoxide of manganese, which is insoluble in dilute sulphuric acid, gave with strong acid a salt of the protoxide of manganese, or, as he called it, a phlogisticated salt. In like manner, with reference to the decomposition of nitrate of potash with sulphuric acid, he accounted for the red vapors produced by assigning a role in the reaction to phlogiston derived from heat traversing the walls of the flask. Combustion he believed was the union of the oxygen of the air with the phlogiston of the burning bodies, a combination which produced the heat. This heat he believed radiated or passed out and away through the walls of the flask, and thus produced a partial vacuum in cases where phosphorus or hydrogen was burned in closed vessels. He further endeavored to account for light on the phlogiston theory, and in the course of his work observed the coloration of silver chloride when exposed to actinic rays; an observation of merit as relating to the subsequent discoveries of Daguerre and his followers in photography, though Scheele's explanation was a false one.

The phenomena of phosphorescence next claimed his attention, both fluorspar and sulphide of barium being the subjects of his researches. Pyrophore, a mixture of sulphide of potassium and carbon finely powdered, was examined. He correctly attributed its spontaneous inflammation to the moisture of the air, but invoked the unfortunate phlogiston to eke out his explanation. Still, his theories come wonderfully close to the truth; and by accepting phlogiston as the general equivalent of sulphur, phosphorus, hydrogen, and other inflammable bodies, Scheele's explanations come still closer.

His researches on fulminating gold included an examination of the gases produced in its explosion. To attenuate the force of the detonation, he mixed it with sulphate of potash. *Vitiated air* (nitrogen) he found



CARL WILHELM SCHEELE.
(*Ungdoms-Vännen.*)

was formed. He concluded that fulminating gold was composed of oxide of gold and ammonia; the latter was composed of *vitiated air* and phlogiston. In the combustion the heat produced phlogiston and oxide of gold; from this came metallic gold, while the oxygen of the heat consumed the ammonia so as to develop nitrogen. In this way he demonstrated the composition of ammonia to be nitrogen and phlogiston or hydrogen. The latter he held to be a pure form of phlogiston.

Sulphureted hydrogen was already known to chemists. Scheele examined it, and devised the present way of preparing it, by acting on sulphide of iron with sulphuric acid. By acting on it with chlorine or nitric acid he formed sulphur. He confirmed his analysis by synthetically preparing it by heating sulphur with hydrogen.

Scheele's theories of combustion certainly attracted the attention of his contemporaries, but they have played no part in the development of science, for the reason that shortly after the publication of his book on *Air and Fire*, the classic researches of Lavoisier were received with acclamation by the scientific world. This does not affect Scheele's pre-eminent standing as a discoverer of facts.

Besides the celebrated work just named, Scheele published a number of treatises on special subjects, many of which were of the utmost importance in the development of chemistry. The majority are contained in the *Transactions of the Royal Academy of Stockholm*, and have been translated into several languages.

In 1771 he discovered that fluorspar treated with sulphuric acid gives a characteristic acid, different from others, and one that possesses the singular property of attacking glass. By combining this acid with lime he again obtained fluorspar. Encouraged by Bergmann he investigated binoxide of manganese (pyrolusite). He proved it to contain an unknown metal, manganese; he found as an associated mineral or impurity baryta. More important still, he found that, treated with hydrochloric acid, it evolved chlorine. This discovery rivals in importance that of oxygen. The application of chlorine to bleaching is one of the largest industries of modern chemistry. He even tried to produce metallic manganese, but not having at command the necessary "*heat of hell*," did not succeed. Chlorine he reported as a gas "of very penetrating odor, acting strongly on the lungs." He collected it in a bladder, but it was attacked. He attached empty flasks to his retort by bands of paper, which bands were attacked. He persevered, and found that it killed insects, extinguished fire, and corroded metals. He observed its bleaching action on flowers, on litmus, and vegetable colors. Again he had recourse to phlogiston to explain its action; but, if we place hydrogen for phlogiston, his explanation will appear quite correct. Berthollet, the French chemist, seconded this discovery in introducing the use of chlorine as a bleaching agent.

In experimenting with chlorine he used arsenic, and thus was led to the discovery of arseniureted hydrogen. In his experiments he produced it by acting on zinc with arsenic acid. He mixed it with air and exploded a large volume, thereby precipitating metallic arsenic that coated his hand. Thus imprudently did he work with this dreadfully poisonous gas, that killed Gehlen, forty years later.

It is well known that phosphorus is a substance that causes iron to break readily when it is cold; technically speaking, it renders it "cold short." Meyer in Stettin and Bergmann in Upsal (1780) both are entitled to this discovery. They found that on dissolving cold short iron in dilute sulphuric acid, a white residue remained. This residue treated with carbon and fluorine gave a friable and readily fusible metal that Meyer called *hydrosiderum*, but which he found later presented some analogies with phosphide of iron. Scheele showed in 1785, by separating phosphorus from cold short iron, that phosphorus was the cause of this property.

Up to Scheele's time, the most incorrect ideas prevailed concerning argillaceous earth, or clay. Alumina, its base, was, by Beaumé, considered to be silicic acid. Scheele, in 1776, distinguished silicic acid from alumina. He fused rock crystal with potash. Dissolving the mass in sulphuric acid, he obtained a little alum, but he was sagacious enough to attribute this to the clay crucible in which the fusion had been conducted. Thus he demonstrated the cause of Beaumé's error.

Plumbago was a subject of investigation with him. He found that while acids in general did not affect it, arsenic acid and also nitrate of potash caused it to disappear. He caught the gas evolved in a bladder, and found it was carbonic acid gas. Hence he drew the conclusion that "graphite is a species of mineral sulphur or carbon, composed of carbonic acid and of a great quantity of phlogiston," or in our terminology it is composed of carbon. He proved its presence in cast iron, it appearing as a residue when the latter was dissolved in acids. Molybdenite, or sulphide of molybdenum, resembling graphite in its appearance, he found, in 1778, to contain sulphur and another substance that gave on oxidation a white earth with acid properties. He suspected the presence of "a metallic earth" in this substance, but he went no further. Molybdenum was the metal thus suspected by him to be present. Tungsten, similar to molybdenum, was investigated. He found it in a white mineral from the Bispberg mines, and showed the points of resemblance and difference between tungstic and molybdic acids. In his honor, tungsten was, for a time, called schelium.

He discovered the method of preparing calomel in the wet way by precipitation. This preparation was the subject of a communication following his only appearance at the Royal Academy of Sciences in Stockholm.

His classic researches on Prussian blue deserve notice. The secret of its preparation had been published by Woodward in 1724. Scheele examined the ammoniacal potash, or "blood lye," with which the color is prepared, and which consists of a solution of cyanide of potassium. He found that on exposure to the air it lost its property of giving a precipitate of Prussian blue with iron salts. This change he found did not take place in closed vessels, and hence he attributed it to carbonic acid. Filling a flask with this gas, and introducing the cyanide solution, he found that it was very quickly decomposed. But a piece of paper impregnated with oxide of iron and suspended in the upper part of the flask gave, when moistened with sulphuric acid, a blue color. Hence he assumed that the coloring agent was volatile. He then distilled a quantity of the blood lye with sulphuric acid. Boiling Prussian blue with oxide of mercury and water he obtained a solution of cyanide of mercury, which he decomposed by iron and sulphuric acid. These processes gave him a colorless liquid of which he wrote: "This substance possesses a peculiar and not disagreeable odor; its taste resembles slightly that of sugar; it warms the mouth slightly and causes coughing." As in the case of arseniureted hydrogen, he did not know how terribly dangerous a material he was handling. The combustibility of hydrocyanic acid vapors with the production of carbonic acid made him conclude that the acid contained carbonic acid and phlogiston.

Aldehyde, acetic ether, and probably chloral were found by him. Glycerine was his discovery; the prevention, by heating, of the alteration of vinegar, described by him, forestalled the work of modern biologists. Citric, malic, tartaric, mucic, uric, and saccharic acids were his discoveries.

Fig. 1 shows the pharmacy at Koeping, where he

FIG. 1.

died. After a hard struggle he had obtained a clear title to it, only to expire before fairly enjoying it, two days after his marriage. He loved the city. Speaking of offers made to him to leave it, he said: "I can only eat what my appetite permits me, and if possible I will do so at Koeping. I have no need of seeking it elsewhere." To his brother he wrote, apropos of an offer to go to Berlin: "I am surprised that you heard of the salary (1,200 riksd.) offered me in Berlin. It is true that this offer was made to me three years ago; but after full reflection I declined it. I am far from being sufficiently advanced in the study of chemistry for such an engagement, and I believe that even in Koeping I can find my daily bread." He was buried at Koeping, but his tomb is not known with certainty.

Fig. 2 shows some of his apparatus, just such as may

FIG. 2.

still be seen in drug stores to-day. Fig. 3 shows his apparatus for preparing oxygen, where he collects the gas in a bladder. Priestley devised the hydraulic trough, so immeasurably superior to this crude method.

FIG. 3.

Finally, his use of bladders is very curiously illustrated in Fig. 4, where his method of making carbonic acid gas is shown. He placed limestone in the bottom of a bladder, and tied a ligature tightly around it just above it. Then he introduced acid and attached the end of the bladder to the neck of his vessel. On loosening the ligature the acid reached the limestone, and, reacting on it, set free the gas. To use bladders for nitric oxide gas, he oiled their interior. To make the gas he put fragments of copper into the bladder, and squeezing out the air, tied it with its opening over and including a small glass containing nitric acid. On shaking the metal into the glass, nitric oxide was evolved and filled the bladder. To fill a flask from a bladder full of gas he filled the flask with water, tied the mouth of the bladder over that of the flask, and inverted the flask, thus transferring the gas. The use of bladders was most characteristic of his work.

In 1778 he was elected a member of the Society of Naturalists of Berlin; in 1784 he was received into the Academy of Sciences of Turin, in presence of Gustavus III. The Academy of Sciences of Stockholm decreed him an annual pension of 100 riksd. ($27). In 1827 a monument was erected to his memory in the choir of the church at Koeping. In 1790 a medal was struck in his honor by order of the Royal Academy of Sciences. The Swedish Academy did the same in 1827.

His collection of books was limited to a few volumes on chemistry and pharmacy. His work was the fruit of his native genius, working under a rule he thus

FIG. 4.

enunciated: "As regards all assertions in chemistry, I have the habit of believing none without personal verification." He was very religious, and accepted his death, when announced to him by his pastor, saying, "Almighty God, am I then so near my deliverance? Behold me, oh Lord, thanks to Thee who hast always extended Thy hand over me, to Thee who hast brought me so wonderfully to the tomb. How often has my heart forgotten its duty and its salvation. Notwithstanding this, Thou, holy of holies, hast not condemned Thy servant. Take the praises my dying tongue can murmur. I am far too humble for the grace and mercy Thou hast always shown me."

To the present generation Scheele must stand as a model of a working chemist. Fettered by the phlogiston theory, by indefatigable labor he did the best work of any discoverer in the development of the facts of chemistry. A student of to-day could hardly go through a better course of chemistry than would be involved in repeating Scheele's work step by step, of course with approved apparatus and explaining each step by the accepted theories.

The following are the titles and subjects of his published works:

1. (1771) Fluospar and its Acid. 2. (1774) "Braunstein" or Magnesia [Manganese], two papers. 3. (1775) Benzoin Salt [Benzoic Acid]. 4. Arsenic and its Acid. 5. Silica, Alumina, and Alum. 6. Urinary Calculi. 7. (1777) Chemical Treatise on Air and Fire. 8. (1778) Wet Process for Preparing Mercurius Dulcis [Calomel]. 9. Simple Process for Preparing Pulvis Algarothi [oxychloride of antimony]. 10. Molybdenum. 11. Preparation of a New Green Color. 12. (1779) On the Quantity of Pure Air Daily Present in the Atmosphere. 13. Decomposition of Neutral Salts by Lime or Iron. 14. Plumbago. 15. Heavy-spar. 16. (1780) Fluospar. 17. Milk and its Acid. 18. Acid of Milk-sugar. 19. On the Relationship of Bodies. 20. (1781) Tungsten. 21. The Combustible Substance in Crude Lime. 22. Preparation of White Lead. 23. (1782) Ether. 24. Preservation of Vinegar. 25. Coloring Matter in Berlin Blue. 26. (1783) Berlin Blue. 27. Peculiar Sweet Principle from Oils and Fats [Glycerin]. 28. (1784) Attempt to Crystallize Lemon Juice. 29. Constituents of Rhubarb-earth [Calcium Oxalate] and Preparation of Acetosella Acid [Oxalic Acid]. 30. The Coloring "Middle-salt" of "Blood-lye" [Yellow Prussiate of Potassium]. 31. Air-acid [Carbonic Acid]; Benzoic Acid. Lapis infernalis. 32. Sweet Principle from Oils and Fats. Air acid. 33. (1785) Acid of Fruits, especially of Raspberry. 34. Phosphate of Iron; and Pearl-salt. 35. Occurrence of Rhubarb-earth [see 29] in Various Plants. 36. Preparation of Magnesia alba. 37. Fulminating Gold. Corn-oil [Fusel-oil]. Calomel. 38. Air-acid. 39. Lead-amalgam. 40. Vinegar-naphtha. 41. Lime. Ammonia or Volatile Alkali. 42. Malic Acid and Citric Acid. 43. Air, Fire, and Water. 44. (1786) The Essential Salt of Galls [Gallic Acid]. 45. Nitric Acid. 46. Oxide of Lead. Fuming Sulphuric Acid. 47. Pyrophorus. 48. Peculiarities of Hydrofluoric Acid.

The profile is taken from a woodcut accompanying his biography, published some twelve years ago in the Swedish "Familjejournal." The full face is reproduced from a portrait in the *Ungdoms Vännen*. Every existing portrait of Scheele, with the exception of perhaps one, has been ascertained to have been sketched after his death, from memory. The exception is a portrait painted upon ivory, at present in the possession of a Berlin painter, Mr. Brüggemann. The search after an authentic portrait of Scheele has become an important matter, as it is to be used in modeling his features for a statue to be erected in Stockholm.

OUTLINES OF A NEW ATOMIC THEORY.

By Dr. T. L. PHIPSON, F.C.S., etc.

IN what follows, the term *phlogiston* is used in a somewhat different sense to that in which it was employed by the older chemists. Some other term might have been equally acceptable, but this one already belongs to chemistry, and, therefore, we have a predilection for it.

On a general survey of organic and inorganic nature, our attention is arrested by a number of facts, which, though they have hitherto defied explanation, the present considerations appear to account for, so far as we can account for anything by connecting facts with theory. Nevertheless, the theory we now put forth does not necessitate any great change in the nomenclature or teaching of chemistry; if it represent truth, it should be given to the world, though for many years we have hesitated to publish it.

In chemistry we have an immense list of substances, all of which present themselves as colorless fluids or white powders, though differing as widely in their properties as pure water and prussic acid on the one hand, or arsenious acid and sugar on the other. Wine-glasses filled with water, alcohol, ether, sulphuric acid,

solution of potash, etc., present no difference to a child or a savage; neither would their contents be considered anything else than water if they contained a solution of some nitrate, chlorate, sulphate, sugar, strychnine, veratrine, ammonia, cyanide of mercury, and so forth. In like manner, all the metals present what is termed the "metallic aspect;" they all show a great similarity of physical and chemical properties, so that tin, silver, cadmium, zinc, antimony, sodium, magnesium, aluminum, lead, etc., would readily be mistaken one for the other by a child or inexperienced person. Again, the alkaloids, sugars, glucosides, essences, etc., all present a great similarity in their physical and chemical properties, a likeness which extends to their therapeutic qualities also.

Another fact, which has often struck chemical philosophers, but has hitherto baffled all attempts at explanation, is that of all the numerous *elements*, or simple bodies, which compose our globe, *four alone* are found sufficient to build up the whole of *organic nature*, and to form the thousands upon thousands of substances known as *organic compounds*.

One more fact, which is amply demonstrated by the numerous analyses given in one of our works, is that meteors or aerolites coming from distant regions of space bring no unknown matter to our globe; they are composed of the *same materials* as our earth. It will be seen by what follows that the same materials may possess *different properties*, according to the circumstances in which they are placed.

A phenomenon readily explained by our new atomic theory, though it has hitherto not been accounted for satisfactorily by any hypothesis, is that observed when two substances of heterogeneous natures, such as two metals, are brought into contact; an electric current, or electric, calorific, or magnetic manifestations immediately occur.

The old notion that matter is composed of "atoms and spaces" is doubtless correct, and it can be argued successfully that atoms are extremely minute spheres. When one substance is divided by another (as when an apple is cut by a knife), the latter passes between the atoms, for *matter is impenetrable*, that is say, the same space cannot be occupied at the same time by two groups of matter, or by two substances; one must make room for the other, and the *space between the atoms* is what we designate as *phlogiston*.

The whole question of the atomic constitution of matter is contained in the theory of equal gaseous volumes, or better, of the *combining volumes of matter in the state of gas*. When we consider this subject, we are met at once by a dilemma. Physical experiment having shown that between certain limits of temperature equal gaseous volumes dilate or contract equally for equal amounts of heat or pressure, it was argued that equal volumes of gases contain the *same number of atoms* of the *same size* and placed at the *same distance* apart. This, of course, implies that the atoms are of *different weights* (for instance, the atom of H weighing 1, that of N weighs 14, etc.)

But it soon came to be seen that this could not be, because in equal volumes of certain compound gases we know that there cannot be an equal number of atoms.

The next supposition was that the atoms in equal gaseous volumes may be of *different sizes*. Thus the atom of H would be 14 times smaller than the atom of N, etc. There is nothing to be said against this hypothesis, except that it does not explain anything; it merely asserts that the atom of N is 14 times as heavy as the atom of H, because it contains 14 times more matter. This notion is, on many accounts, improbable, unphilosophical, and explains nothing. But another proposition, which we shall now put forward, does explain a number of phenomena that otherwise we find it impossible to account for.

This proposition is that equal gaseous volumes contain a *different number of atoms* all of the *same size* and *same weight*. This implies that the atoms are all of the *same nature*, and proclaims the *unity of matter*.

Whatever substance may be under consideration, its atoms are all of the same nature, and they are separated by space, which we call *phlogiston*, a term that implies movement, light, heat, electricity, etc. The greater the amount of *phlogiston*, the greater the *energy* of the system of atoms termed *element*. Thus H is the most energetic system of atoms yet known; it has the greatest amount of phlogiston; in other terms, the motion of its atoms is the most extensive.

The matter of all the *elements* is, therefore, identical; *the phlogiston alone varies*, that is, the *distance* or *space* between the atoms (considered at rest), or their *extent of motion*.

A chemical *element* is, therefore, a *system of atoms*, the nature or properties of which system depends on its phlogiston, and the amount of the latter is deduced directly from the balance—from the *weights which combine together*. Thus, in equal gaseous volumes of H, N, Cl, etc., we admit that there exist, say, 10, 140, 350 atoms of the *same size, same weight*, and *same nature;* and if we could volatilize without decomposing solid bodies, such as sulphate of iron, for instance, so as to consider them under the same gaseous volume, we should find the same law hold good for them, and that an equal gaseous volume of ferrous sulphate, for example, would give, as compared with the substances above named, 760 atoms of the same nature as those of H, N, or Cl.

It will be seen by this that the *properties of a substance* depend not on different kinds of matter, but on the different amounts of *phlogiston* that separate the atoms and cause them to move in certain set systems. The atomic system called H is different from the atomic system called N, because the atoms of the latter system are separated by less space; the system possesses less phlogiston.

We thus see that, as everything depends on gravitation, the systems of atoms (elements) known as iron, oxygen, sulphur, etc., on this globe may possess very different properties on the planets Venus or Jupiter, for instance, on account of the different distances of these planets and our globe from the sun.

Spectral analysis, like the fall of aerolites, proves that the same nature of atoms exists in far off globes as with us; but we see that the properties of a substance depend on its *phlogiston*, which, in its turn, depends on gravitation, so that, although the matter is identical with that of our earth, the physical and chemical properties must be different from what they are upon this globe.

We also see how the whole *organic world* is made up of a few systems of atoms (elements) only; they are those which contain the *most phlogiston*, and consequently possess the most energy; they constitute the nearest approach to *vitality*.

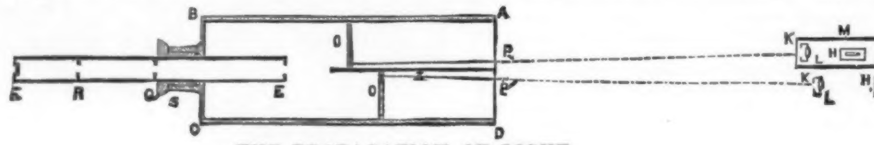
Again, when two heterogeneous systems of atoms are brought in contact, a vibration ensues such as astronomers have termed *perturbation;* it is caused by a slight *deviation of the movement*, a slight *change in the phlogiston* (which may be temporary or permanent), and is carried away along a "conductor," in the form of what is called an electric current, or otherwise. In *allotropic* bodies the original phlogiston is more or less permanently modified; and, could this allotropism be pushed far enough, the "transmutation" of the elements would undoubtedly ensue.

It will be perceived that this theory explains a mass of facts which are not even alluded to in the foregoing notes; and though it leaves unaccounted for a certain number of physical phenomena, these will probably be explained in time without disturbing it.

PROPAGATION OF LIGHT.

By J. H. POYNTING, M.A., and E. F. J. LOVE, B.A., Birmingham.

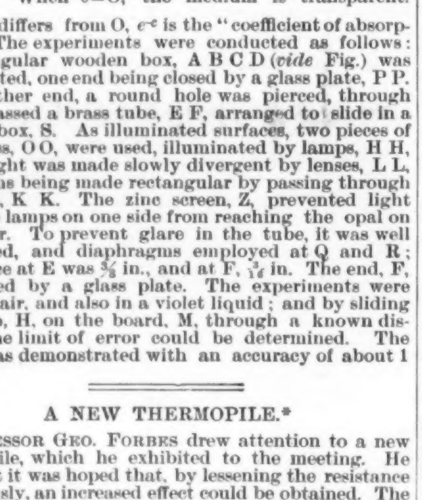
THE paper describes a new method of proving that the intensity of illumination of a screen varies inversely as the square of the distance from the source. The same experimental arrangement, with slight modification, allows us also to prove the law of absorption of light—a law which, we believe, has hitherto been assumed without verification by experiment. The principle of the method is as follows: Two illuminating surfaces at different distances are viewed through a narrow blackened tube, each surface occupying half the field of view. The illuminating powers of the two surfaces are adjusted, till for a given distance of the tube they appear equally bright. They then appear equally bright for any other distance of the tube. This was verified, both for air and for an absorbing medium consisting of a dilute alkaline solution of phenol-phthalein, which colored the transmitted light violet. From this it can be shown that if I be the intensity of illumination of a screen at distance 1 from the source, the illumination at a distance x is $\frac{I e^{-c(x-1)}}{x^2}$ When $c=O$, the medium is transparent. When c differs from O, e^{-c} is the "coefficient of absorption." The experiments were conducted as follows: A rectangular wooden box, A B C D (*vide* Fig.) was constructed, one end being closed by a glass plate, P P. In the other end, a round hole was pierced, through which passed a brass tube, E F, arranged to slide in a stuffing box, S. As illuminated surfaces, two pieces of opal glass, O O, were used, illuminated by lamps, H H, whose light was made slowly divergent by lenses, L L, the beams being made rectangular by passing through the slits, K K. The zinc screen, Z, prevented light from the lamps on one side from reaching the opal on the other. To prevent glare in the tube, it was well blackened, and diaphragms employed at Q and R; the orifice at E was ¾ in., and at F, $\frac{1}{16}$ in. The end, F, was closed by a glass plate. The experiments were made in air, and also in a violet liquid; and by sliding the lamp, H, on the board, M, through a known distance, the limit of error could be determined. The result was demonstrated with an accuracy of about 1 in 1,000.



THE PROPAGATION OF LIGHT.

A NEW THERMOPILE.*

PROFESSOR GEO. FORBES drew attention to a new thermopile, which he exhibited to the meeting. He said that it was hoped that, by lessening the resistance enormously, an increased effect could be obtained. The result seemed to have justified the theoretical conclusion. He said that the instrument consisted of a blunt-ended wedge of antimony placed upon a wedge of



bismuth; very near the thin end of the composite wedge was a horizontal hole, in which was suspended a reflecting needle, as represented in the cut. The instrument is very sensitive as a line thermopile, and is very dead beat in its action, so that it comes to rest rapidly. One of the light mirrors of Mr. White, of Glasgow, is used in it. He could not conceive how any one could use heavier mirrors. He made the needle astatic by another set of magnets. It then proved more sensitive, but not so dead beat.

Professor Fitzgerald wished to know what was the relative delicacy of thermopiles and bolometers. Langley had given preference to bolometers; but Professor Forbes had said that the instrument before them was as sensitive as any other.

Professor Forbes had only been comparing the thermopile before them with other thermopiles. He believed the bolometer to be much more accurate.

Lord Rosse thought Professor Fitzgerald's problem to be worth going into. He (Lord Rosse) was trying to find out what the merits of the bolometer were, and, in looking carefully over Langley's paper, he was disposed to think that the value of the bolometer had been exaggerated. Langley laid great stress upon improvements in his galvanometer. He used the two wings of dragon flies to make it give a dead beat; it then came to rest, after giving two or three oscillations. He (the speaker) used a thermopile of low resistance and large wires, leading down into the observatory.

Lord Rayleigh was under the impression that Langley's improved results were due more to the galvanometer than to the other instrument. For a thin wire linear instrument to investigate the spectrum, perhaps a thermal couple of equally thin wires might be substituted. Once he had tried Lord Rosse's plan of employing a large disk to receive the heat, and to then transfer it to the thermal junction. It answered well.

Lord Rosse said that the comparison Langley had drawn between two methods of estimating the heat of the lunar rays was hardly a fair one. He (the speaker) had a large mirror to work with in the open air, while Langley worked in an observatory. One could hardly draw a comparison between two such sets of radiation experiments.

Professor Forbes added that a modification of this thermopile had been made by cutting away some of the two metals and replacing them with copper, so that one thick piece of copper was at the top of the couple and another at the bottom, to increase the conductivity.

* Paper read before the British Association, Section A, Birmingham meeting, 1886.

PRODUCTION OF NICKEL.

ONLY a few years ago, industrial circles were aroused by the discovery in New Caledonia of highly important deposits of nickel. A company was formed in France to work them, acquiring the patents of Garnier, building works for treating the ore and refining the metal at Septemes, near Marseilles, where the vessels from Nourmea discharged. Later these works were abandoned for a plant at Birmingham. The capital was increased, an alliance formed with a great metallurgical establishment at Glasgow to work other metals besides, like chrome, cobalt, antimony, etc. The abundance and the richness of the New Caledonia deposits, and the strong financial backing which the enterprise had, seemed to assure for it a bright future. It was expected that nickel, produced at a low price, would in many directions displace copper, and that the production would keep pace with the steadily growing consumption at gradually declining prices. Such, according to M. Charles du Peloux, in the *Genie Civil*, was the outlook in 1882. Now, the works at Nourmea are closed, and work at the mines is reduced to what is absolutely necessary.

The ore, known as "garnievite," is a hydrosilicate of nickel and magnesia, and is found at a great number of points in Caledonia; in fact, it may be stated that, with the exception of the northeast end, traces of nickel may be found in all parts of the island, which is made up of more or less decomposed eruptive rocks, among which serpentine plays the most important part. The nickel ore is always found in the beds of serpentine. Still, though apparently so abundant, the ore is found in quantity and accessible in workable deposits only at a very few points in the districts along the northeast coast of the island. After examination these rich regions are reduced to three principal districts, named Canala-Méré-Kuana, Thio-Port Bouquet, and Bourindi.

The Thio group is the only one now being worked, and is the best known, and is considerably nearer Nourmea. Although it has been well opened out in all directions during the past six years, it is far from being exhausted. The third district, the Bourindi, is probably justly considered the richest on the island, both for quantity and grade of ore. It is nearest Nourmea, and has not been touched as yet. It is kept as a reserve.

The veins, so far as strike and dip are concerned, are fairly regular, striking north-northeast and south-southwest, and dipping almost vertically. But the contents vary widely and suddenly in grade. The veins are not very persistent, and it is asserted, after an experience which must be considered final, that in depth they do not descend deeper than 300 to 500 feet, that depth even being very rare. The ore is mined by the usual methods, and is hand-sorted at the mine and sacked. M. Du Peloux describes in detail how frequently the ore is handled, evidently disapproving of it. He enumerates that the ore of the Thio district—best equipped with means of transportation—is handled twelve times. This is partly due to the fact that the sacks are taken to the river bank, the bar at the mouth of which they can only cross at flood tide, and that the beach is so shallow that the ore must again be lightered to the sea-going vessels in the offing, who carry it to Nourmea, where the smelting works are located. Thus the irregularity of the ore distribution and the high cost of transportation carry the expense of mining high. To this must be added the scarcity of suitable labor in New Caledonia. Among the force available are, first, those criminals transported who are liberated with residence restricted to the colony. They are lazy and difficult to handle. They get from six to nine francs for eight hours' work. Then there are the natives of the New Hebrides Islands, engaged under supervision of the government for a period of three to five years. Although apparently cheap labor, they cost three francs a day, are unfit to work in the

mines, and are unable to adapt themselves to the climate, from twenty-five to thirty per cent. always being in the hospital, where the majority die. Their immigration has been finally prohibited by the French government. The Australians are fair miners and good workmen, but they demand at least 12·50 francs a day. Latterly Chinese laborers have been brought in, and they promise better, although they require constant watching. Added to the high cost of labor, as compared with European standards, there is often trouble through want of water.

The ore is taken in lots of 200 to 250 tons to Nourmea, where it is worked in two blast-furnaces, one of which is used for nickel ores alone, and the other for mixed ores of nickel and cobalt. The charcoal and coke come from Australia, and, in spite of the proximity of the two colonies, are very dear. Charcoal costing 12·50 francs at Sydney is worth 40 francs at Nourmea, while coke sells at 70 to 80 francs. The object of the smelting of the ore is to produce a math carrying from 60 to 70 per cent. of metal. It is granulated and shipped to England.

The production of nickel is far greater than the consumption, and that is the principal reason which has led to the temporary suspension of the working. The sale of the metal was considered too easy a matter. Production was pushed too fast, and thus the company were finally brought face to face with an enormous stock. In April, 1884, the product of the Thio mines had reached 1,000 tons a month, and orders came to increase it even then. With the usual grade, this represented an annual production of 850 tons of metal. During the years 1882, 1883, and 1884 the Caledonia Company have thrown on the market about 2,400 tons of pure nickel. It may be estimated that in those three years the European and American mines marketed a total of 600 tons, carrying the aggregate for three years to 3,000 tons, or 1,000 tons per annum. Now the consumption is probably not greater than 700 to 800 tons, if it does reach that figure. At present prices, ranging between 6 and 7 francs, the profits are small. M. Du Peloux, however, believes that the cost may be reduced so that the company can sell at 4 to 5 francs and yet have a good profit. In spite of the temporary stoppage, the future is full of promise.

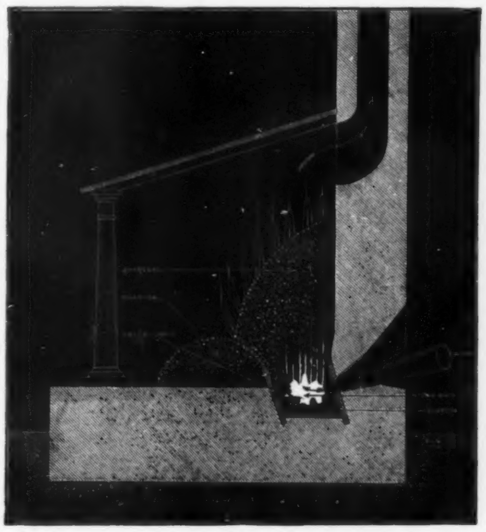
THE BLOOMERY.

THE Catalan process has been by no means confined to the province of Catalonia, or even Spain or Europe. It has been employed to a considerable extent in Vermont and New York to smelt the magnetic ores of those American States, and is commonly known, not as the Catalan forge, but as the "bloomery fire." The hearth is of stonework, 6 ft. or 8 ft. square, at one corner of which is the fireplace, measuring from 24 in. to 30 in. square, and from 15 in. to 20 in. deep, lined inside with cast iron plates, the bottom plate being 2 in. or 3 in thick. There is no "trompe," but the blast is produced by wooden bellows, worked by water wheels. The ore chiefly operated upon is the crystalline magnetic ore, and readily falls to a coarse sand. In the process almost everything depends on the skill and experience of the workmen, and the result is subject to considerable variation, depending on whether the desire is to economize fuel or ore. One workman, by inclining his tuyere to the bottom, saves coal and loses iron. Another workman, by carrying his tuyere more horizontally, especially at the commencement, gets a good yield of iron, but wastes coal. The process itself is simple enough. The hearth is lined with a good coating of charcoal dust, and the fire plate—that is, the plate opposite the blast—is lined with coarse ore—in case there is any coarse ore to be had—but it mostly falls to sand; and if this is so, the hearth is filled with charcoal, and the small ore piled against a dam of charcoal, just opposite the tuyere. The blast is at first urged gently and directly upon the ore, while the charcoal above the tuyere is kept cool. Four hundred pounds of ore is the common charge, two-thirds of which are thus smelted, and the remaining third, generally the finest ore, is held in reserve to be thrown on the charcoal when the fire becomes too brisk. The charcoal is piled to the height of 2 ft, 3 ft., and even 4 ft., according to the amount of ore to be smelted. When the blast has been applied an hour and a half or two hours, most of the iron is melted, and forms a pasty mass at the bottom of the hearth. The blast can now be urged more strongly, and if any pasty or spongy mass yet remains, it may be brought within the range of the blast and melted down. The slag or scoria will flow away through the tapping hole, and by means of iron bars the whole mass of pasty iron is brought before the tuyere. If the iron is too pasty to be lifted, the tuyere is made to dip into the hearth, and in this way the iron is raised from the bottom directly before or to a point above the tuyere, until it becomes welded into a coherent ball 12 in. or 15 in. diameter, and being taken out, passes through the usual processes, and eventually becomes bar iron. The resulting product is not eminently satisfactory, being a mixture of fibrous iron, cast iron, and steel, and this aggregation of irregularities is quite unavoidable, the quality of the iron depending entirely on the quality of the ore, and no opportunities are presented by which any skill or ingenuity can create improvements in the process. Poor ores cannot be smelted at all; rich ores may be smelted to advantage, and even with economy.

Mr. David Mushet (the founder of a family which, in his own person and that of his descendants, has rendered invaluable service to iron and steel manufacture, and one member of which, the very eminent Mr. R. F. Mushet, is still with us, but, to use his own words, "wasting away"), in some exceedingly valuable papers on iron and steel published over half a century ago, and now very rare (and the writer is pleased that, since commencing these notes, a copy has been placed at his disposal), describes the action of these American bloomeries. In the commencement of the operation, the charge of ore is placed opposite and at some distance from the tuyere, with a considerable body of charcoal between, as shown in cut. As this becomes ignited, an imperfect deoxidation commences on that part of the ore charge sheltered by the charcoal, and next to the blast. When this part of the process is considered to be matured, that portion of the ore is moved toward the center of the fire, under the surface of the ignited fuel, which now commences a deoxidating influence upon a more remote part of the charge, and this, when perfected, is also moved forward in its turn. This operation is performed in succession, until the whole charge of ore has been advanced one stage. In the same gradual manner the charge is advanced another stage, which brings the first portion of the ore into the hottest part of the fire, and immediately opposite to the blast, where it begins to coalesce and form itself into lumps of malleable iron. These are upreared to the surface of the fire, and another portion of the charge brought forward, and treated in a similar manner, till the whole charge is resolved into masses of clotted iron and thrown in their turn upon the surface of the fire. These lumps are again and again sunk before the blast at the pleasure of the workman, until he considers that the proper quality of iron has been obtained, when they are welded together and carried to the hammers.

Mr. Mushet estimates that one of these American "bloomeries," with iron ores containing 65 to 70 per cent. of iron, will, in one week, working day and night, make 30 cwt. of iron, consuming 1,200 bushels of charcoal and not obtaining one-half—nor nearly one-half—the quantity of iron contained in the ore, the quantity of charcoal consumed being double that which would be required in the operation of converting the same quantity of malleable iron from pig iron. Mr. Mushet believes that long, long ago these "bloomeries" were common in England.

Sir Isaac Lowthian Bell, in a short reference to the Catalan process, and more especially with regard to the methods of the United States of America, says that in this direct method of dealing with the ore there are two distinct stages through which the mineral has to pass—namely, first, the expulsion of the oxygen with which the iron is associated, and secondly, the raising of the reduced metal to a welding heat in the "bloomery." So far as economy of fuel is concerned, it is essential that the intensely heated gases generated at the tuyeres should communicate as much as possible of their heat to the materials on their way downward in the furnace. Failing this, the loss, as regards economy of fuel, by the gases escaping into the atmosphere at a high temperature, is exceedingly great. The office of reduction being to withdraw oxygen from the ore, it is of the highest importance that the gases near the tuyeres shall be themselves as free from oxygen as possible, otherwise there will be a danger of reoxidizing the metal; and, as a fact, in all arrangements of the Catalan and similar furnaces, much of the mineral is deoxidized at or near the tuyeres. Hence arises the necessity of burning additional quantities of carbon, to give sufficient reducing energy to the gases at this point. Even with this precaution, complete reduction of all the iron is found impracticable, and this is the cause of so great a proportion of the metal being carried off as slag in low structures, such as Catalan and "bloomery" arrangements, in which, from the very nature of the apparatus, the operations are all necessarily most inefficiently performed. But after dealing with the glaring inefficiencies and imperfections of the direct process, Sir Lowthian shows that there are advantages. In most iron ores phosphorus is found, existing either as a phosphate of iron or a phosphate of lime, and it is very desirable that in the finished product this phosphorus should disappear. The direct process possesses the desideratum of giving a product comparatively free from phosphorus, because, owing to the partially oxidizing tendency of the operation, the phosphates are chiefly left in the slag. Hence, now that steel more than iron is the aim of our manufacturers, the direct process and how to obtain its advantages and avoid its defects has occupied and even now occupies a good deal of attention, and many plans have been proposed which we shall deal with later.



AN AMERICAN BLOOMERY.

Professor Osborn, in an American work, and Professor Kerl, in a German work, both give excellent descriptions and illustrations of this modified Catalan furnace, or as named in the United States, "bloomery fires," from which, with some alterations, we have taken our engraving. In our next article we shall show the Osmund and the Stuckofen.

(*To be continued*).

THE *Fireman's Herald* states that "there is hardly a store or shop of any description in the smaller towns that has not either an unsafe flue or stove or stovepipe, or a pile of old boxes and rubbish, including straw and waste paper, intermingled with wooden ash boxes, in the rear or on adjoining lots. Fires get started in these places, and as the rubbish extends in the rear yards from street to street, the whole block is burned out." Many a conflagration might be prevented if people would be more careful about leaving combustible material in their cellars, storerooms, and back yards.

ON THE CONNECTION BETWEEN CHEMICAL CONSTITUTION AND PHYSIOLOGICAL ACTION.*

By THOMAS LAUDER BRUNTON, M.D.

THE meeting of the British Medical Association is not for mutual instruction only, it is also for recreation; and, probably, many members of this association will utilize the opportunity which a meeting at the seaside, like the present one at Brighton, affords them of indulging in that excellent occupation for an idle man—of watching the waves on the seashore and speculating how far each of them will come. If one have only half an hour to spare, it is difficult to say whether the tide is ebbing or flowing; it is only by watching for a longer time that one can be certain that the water is really moving in one direction or another. Probably a great part of the charm which this occupation possesses is due to the resemblance which one involuntarily traces between the ebb and flow of waters and that of human affairs—individual, national, or racial. The life of a single man is very short in comparison with the history of the race; and it is often very difficult to say whether mankind is advancing or retrograding, unless we compare his condition at epochs widely removed from one another.

On doing this, we find a general consensus of opinion to the effect that civilization has steadily advanced; and this advancement is usually divided into four stages, characterized by the nature of the tools or weapons employed. In the first, or Palæolithic Age, man employed weapons or tools of flint roughly chipped into shape and unpolished. In the next, or Neolithic Age, the implements consisted of stone, but they were polished. The next age is characterized by the employment of bronze as a material, and the fourth and highest stage by the employment of iron. These stages are not all marked off from one another, for we find them together in the same country or in different countries. Thus, the age in which at present we live is recognized as the Iron Age, on account of the large employment of that metal; but we find that in various countries stone, more or less rudely fashioned, is still used in the manufacture of weapons or tools. For example, when I was in the Colonial Exhibition lately with Mr. Norman Lockyer, he pointed out a kind of thrashing instrument, such as is now used in Cyprus. It consists of a flat board, in the under side of which are embedded a number of stone celts exactly like those made by prehistoric man, and perhaps used by him for a similar purpose as well as for axes. In the same way that we recognize four stages in the development of the implements used by man in the arts or in warfare, we may, I think, recognize four stages in the development of the implements he has used in the treatment of disease. In the first stage crude drugs were employed, prepared in the roughest manner, such as powdered cinchona or metallic antimony. In the next stage these were converted into more active and more manageable forms, such as extracts or solutions, watery or alcoholic. In the third stage the pure active principles, separated from the crude drugs, were employed, *e. g.*, morphine and quinine. In the fourth stage, instead of attempting to extract our medicines from the natural products in which they are contained, we seek to make for ourselves such substances as shall possess the particular action we desire. Now, just as we find stone and iron implements occasionally used together in the same country, so we find that drugs belonging to the different stages mentioned are used at the same time. For example, we may find crude powders, alcoholic extracts, and pure alkaloids all contained in the same pill. Nay, more, we may sometimes give to the patient, in addition to all these, a medicine made artificially. But, while this condition still exists, we notice that crude drugs are being less and less used, and their place is gradually being taken by pure active principles. We may say, then, that we are passing at present from the stone age to the bronze age of pharmacology, and may indeed be said to be just entering on the iron age. This age may be said to have begun about twenty years ago, when the researches which my predecessor in this office, Dr. Fraser, made with Prof. Crum Brown, upon the connection between physiological action and chemical constitution, inaugurated a new era in pharmacology. They found that, by modifying the chemical constitution of strychnine, they could also alter its physiological action, and convert it from a poison which would tetanize the spinal cord into one which would paralyze the motor nerves.

We might perhaps date the beginning of this age from Blake's attempts to show that a connection exists between the form in which various bodies crystallize and the mode in which they act upon an animal body. Richardson, too, had observed that, among various compounds of carbon, certain differences existed in physiological action which might be supposed to correspond to differences in their chemical composition. And at the same time that Crum Brown and Fraser were making their experiments, Schroff in Vienna, and Jolyet and Cahours in France, had independently arrived at somewhat similar conclusions; nevertheless, I think we may fairly say that it was the experiments of Crum Brown and Fraser which fairly started pharmacology in the new direction in which it has since been steadily advancing. It would be impossible for me to enter at all fully into the recent development of this branch of research, but I think it may be both interesting and useful to try to give you a short and popular account of the chief points already made out; and, in doing so, I may, perhaps, be excused for using, almost to the extent of abusing, similes which are not precisely exact, but which may be useful in giving you a rough idea of a somewhat complicated subject.

We have all heard of the "flesh-pots of Egypt," but I find that everybody is not acquainted with the "flesh-pots of Shiloh," though "good little Samuel" has probably been frequently held up before us as an example to be followed, and possibly the naughty sons of Eli as an example to be avoided. When these sons of Eli were priests in Shiloh, their custom was, when any man offered a sacrifice, to send their servants with a "flesh-hook" of three teeth, in his hand, which he

* An address delivered at the opening of the Section of Pharmacology and Therapeutics, at the annual meeting of the British Medical Association, held in Brighton, August, 1886. By Thomas Lauder Brunton, M.D., F.R.S., Lecturer on Materia Medica and Therapeutics at St. Bartholomew's Hospital, President of the Section.

struck into the pan, or kettle, or caldron, or pot; and all that the flesh-hooks brought up the priest took for himself.

It is obvious that what the priest's man brought up would depend very greatly on two things, viz., the contents of the pot and the nature of the hook, whether it were large or small, sharp or pointed, single-pronged or many-pronged. It is obvious, too, that a very slight alteration of the points, by the judicious application of a file or whetstone, might considerably influence the savoriness of the priest's dinner. With the small pots that they were likely to have in Shiloh, it would not matter much what the nature of the handle was; but it would matter very greatly if the priests had to go fishing in the brazen sea of Solomon, for there, with a short handle, they might not be able to reach the tidbits in the middle, and if the handle were too long, they might go plunging their hooks about the opposite side of the vessel, with the same result as if the handle were too short. Now, in the drugs which we use in medicine, we may find a certain analogy with these flesh-hooks, some part of the drugs being comparable to the hooks and others to the handle. Perhaps the analogy would be even more correct if we were to regard the hooks as having movable points, which could be taken off and replaced by others of a different form or sharpness. If we take alkaline salts as an example, we may regard the base as the handle and the halogen as the hook; and by modifying either of these, we may alter the parts of the body affected and the manner in which they are affected. We might, indeed, compare chloride of sodium, in which we have the chlorine attached to sodium, with the low molecular weight of 23, to a hook with so short a shank that it did not reach the big joints lying in the middle of the caldron; while potassium, with a molecular weight of 40, was just long enough to do this; and rubidium, with a molecular weight of 85, was so long as to go plunging about on the other side. In fact, we find that this is very nearly what occurs in the muscles of the animal body after the administration of the chlorides of sodium, potassium, or rubidium; for while potassium chloride is a powerful muscular poison, the action of sodium and rubidium chlorides on the muscles is very slight.

We have seen what changes would follow alterations in the shank of our flesh-hook; now let us see the effect of altering the prongs. If we put on a small one like chlorine, it may go dragging about catching everything, but bringing out nothing; a bigger one, like bromine, may lay hold of a lung or a brain; and a bigger one still, like iodine, may lay hold of a big joint. Now, what we find in the body seems to be somewhat similar. The chlorides circulate in the blood without producing any marked alteration beyond that which is due to the substance with which the chlorine is combined. The bromides attack the brain and nerve-centers, and the iodides tend more especially to affect the muscles and the glands.

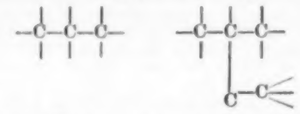
It is evident that another important factor besides the sharpness of the hooks is the number of prongs, and the three-pronged hook seems to be the generally effective one. Now, in pharmacology, there is one substance—nitrogen—which appears sometimes to have three, and sometimes five, prongs, or affinities, as chemists term them, and it is a substance having a very general and powerful influence over the body. When combined with hydrogen in the form of ammonia or of ammoniacal salts, it affects nerve-centers, motor nerves, and muscles, tending first to stimulate and then to paralyze them. But, as we would expect, the effect of the ammonia is modified by its combination with iodine, chlorine, and bromine; and we find that, while the ammonium-chloride generally attacks the spinal cord and causes irritation, ammonium-iodide paralyzes the motor nerves and muscles.

When nitrogen has oxygen combined with it in place of hydrogen, so as to form nitrous acid, its action is exerted more especially upon the blood and blood-vessels, so that it causes the blood to become chocolate-colored, and the blood-vessels to dilate. This power of dilating the vessels is sometimes exceedingly useful in the treatment of disease; and we have been enabled to vary the action of our drugs so as to attain, to a great extent, the end we desire, by our knowledge that the action depends upon the nitrous acid, and not on the substance to which the acid may be attached; or, to return to our own comparison, the effect depends on the nature of the hook rather than on the kind of shank to which it is attached. Thus, where rapid dilation is desired, we use nitrite of amyl; but where a slower and more prolonged action is desirable, we employ nitrite of soda or nitro-glycerine.

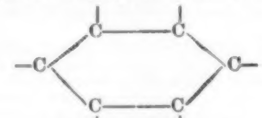
In some useful tools we have the two ends serving different purposes, one end, for example, being a hammer and the other end a claw for extracting nails; and we can easily imagine a flesh-hook constructed on the same principle, one end, let us say, having the prongs widely apart, and the other the prongs close together. With such a hook, it is evident that the viands which were fished up would be different, according as one or other end was put into the pot, for the close prongs would bring up delicate little pieces, which would simply slip through the wide ones. If we carry our illustration a step further, and suppose this hook to consist of two parts attached to one another by certain prongs, while others were left free, we can see that, if only one prong were left free in each part, but these prongs were of different shapes, the pieces obtained by the man using it would be of a different kind, according as the prong belonged to one end or the other. Now we seem to find something of this sort in the union of nitrogen with carbon. Carbon is a substance with four affinities, while nitrogen appears sometimes to have three and sometimes to have five. When the nitrogen and the carbon are united in such a way that four affinities of each are connected together, leaving one free affinity or prong belonging to pentad nitrogen, thus, —N≡C, the compound is exceedingly poisonous; whereas, when the free affinity or prong belongs to the carbon and the other three affinities are joined to triad nitrogen, thus, —C≡N, the compound is comparatively innocuous.

This fact shows us how very important the nature of the free affinity in the compound is in regard to physiological action.

We have just pictured to ourselves an instrument of two parts, joined together by small hooks, and consisting, in fact, of two links. In this instrument the links differ a good deal from each other; but one link —namely, carbon—has a great power of uniting with itself, so as to form long chains, straight or branching, thus:

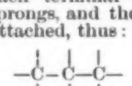


It also forms what we may possibly regard as close chains, so stiff as to act the part of a shank, to which single hooks or long open chains may be attached. We may represent it graphically thus:

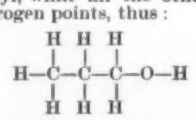


Now, if any of Eli's successors wanted to fish in Solomon's brazen sea with hooks attached to a flexible chain instead of to a stiff shank, the results of his fishing would not only depend on the hooks he used, but on the length of the chain, on the kind of chain, single or branching, and on the position of the links to which the hooks were attached.

Now, in the series of chemical substances to which alcohol belongs, we have an illustration of the modifications in physiological action which are produced by the length of the chain, the kind of chain, and the position of the hooks. The links, in the case of alcohol, consist of carbon atoms attached to each other by one affinity, so that each terminal atom, or link, has three affinities, or prongs, and the intermediate links have two each, unattached, thus:

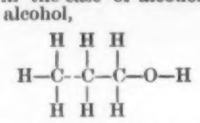


We may regard one prong of one terminal link as furnished with a sharp point, to which we give the name of hydroxyl, while all the others are furnished with blunt hydrogen points, thus:

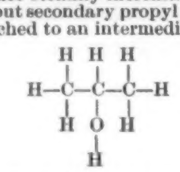


All the alcohols attack the nerve-centers, and paralyze the brain, the spinal cord, and the centers of organic life in the medulla oblongata. In large doses they all produce death, and the longer the chain the more deadly do they become, until the chain is so heavy that it can hardly be used at all, or, in other words, till the alcohol becomes so solid that it will not readily enter the body and produce its toxic action.

If we fix the sharp hydroxyl on one of the intermediate links, instead of the end one, we would naturally expect that it might simply scratch the pieces of meat instead of pulling them out, as it might do if it were attached to the terminal link; and this is exactly what we find in the case of alcohol. For example, primary propyl alcohol,

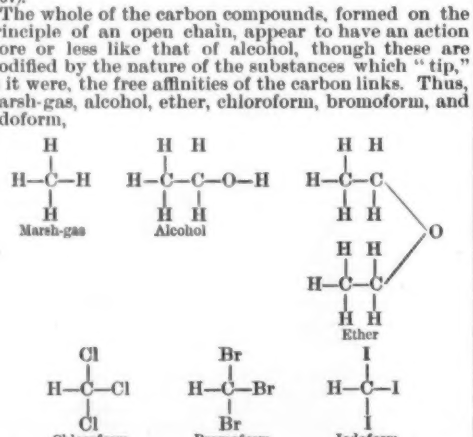


where the hydroxyl is attached to the terminal link, appears to produce steadily increasing paralysis of the nerve-centers; but secondary propyl alcohol, where the hydroxyl is attached to an intermediate link, thus,



scratches up or stimulates the nerve-centers before it paralyzes them (Efron Pflüger's *Archiv*, Band xxxvi., 1467).

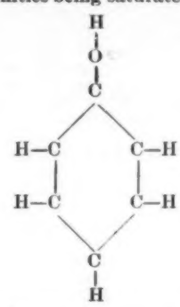
The whole of the carbon compounds, formed on the principle of an open chain, appear to have an action more or less like that of alcohol, though these are modified by the nature of the substances which "tip," as it were, the free affinities of the carbon links. Thus, marsh-gas, alcohol, ether, chloroform, bromoform, and iodoform,



all tend to paralyze nerve-centers, and to exert an anæsthetic action; but the chloral in the chloroform tends to make the substance paralyze the heart more quickly than marsh-gas, alcohol, or ether, which contain hydrogen alone, or hydrogen and oxygen; and in iodoform the effect of the carbon is to a great extent swamped by the iodine.

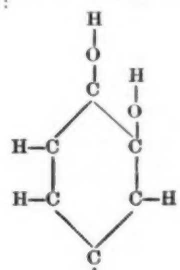
It is to Liebreich's recognition of the fact that similar carbon compounds possess a similar anæsthetic action that we owe the discovery of chloral. The knowledge of the depressing action on the heart of chlorine in such compounds led Schmiedeberg and Cervello to search for a hypnotic substance which should not contain chlorine, with the result that paraldehyde has been added to our therapeutic *armamentarium;* and the stimulant action of ammonia led Schmiedeberg to introduce a new hypnotic, urethane, which, like chloral, will produce sleep, but, instead of weakening, will stimulate the heart, and is thus admissible in cases where chloral might be dangerous.

Let us now turn to the other class of carbon compounds, in which the atoms are arranged so as to form a close chain, or, as we may call it, a stiff nucleus or shank, to which either single hooks or open chains may be attached. This group of carbon compounds is termed the aromatic series. The substances belonging to it differ from those of the open chain or fatty groups, inasmuch as they tend to stimulate the nerve-centers, and produce convulsions or spasms before paralyzing them. But the most marked property which they possess appears to be their power of reducing temperature, and of destroying low forms of life, so that they act both as antipyretics and as antiseptics. We have seen that in the open chains of the fatty series of carbon compounds, the increased number of links appears to increase the activity of the compound, and a condition which is similar, in some respects at least, is to be found in the aromatic series. For example, in phenol or carbolic acid, as it is usually termed, we have one hydroxyl terminal, just as in ordinary alcohol; the other carbon affinities being saturated with hydrogen:

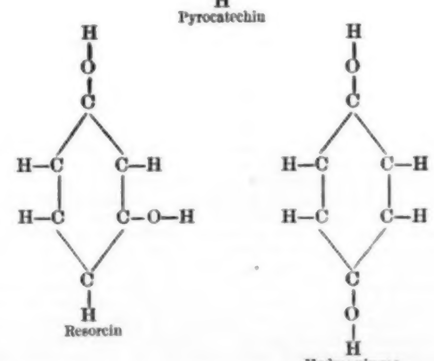


When these hydrogen atoms are replaced by methyl, the antiseptic power of the phenol is increased, and the increase appears to be in proportion to the number of methyl groups which are introduced into the compound. Turning again to our old illustration of the flesh-hooks, we might compare the benzene nucleus to the shank with six points, each of which might be armed either with a sharp hydroxyl hook, or with a blunt hydrogen one, or with a carbon chain. The more the blunt hydrogen hooks were replaced by chains, the more thoroughly would they sweep the pot; and, in fact, we may say that the more chains there are instead of hydrogen, the more thorough is the antiseptic action of the compound.

In the case of antiseptics, all that we want is to insure a thorough destruction of the microbes which give rise to putrefaction or disease; but when we come to deal with antipyretics we have a more complicated problem before us, for we wish to reduce the temperature in man or the higher animals, while at the same time we have to avoid producing any marked action on the nervous system in the way either of spasms or paralysis, and also to avoid depressing the circulation and causing collapse. Now several bodies nearly allied to carbolic acid, and differing from it only in the fact that the benzene nucleus in them has two hydroxyl groups attached to it instead of one, as in carbolic acid, have a strong antiseptic power. These bodies are hydroquinone, resorcin, and pyrocatechin; they all have an antiseptic action, but the strength of their action is very different, resorcin having only one-third of the strength, and pyrocatechin only one-fourth of that of hydroquinone. This difference in strength shows us here, also, how important the position of the hydroxyl groups is; because, in pyrocatechin they are close together, in hydroquinone they are as far apart as they can be, and in resorcin they keep an intermediate position:



Pyrocatechin



Resorcin

Hydroquinone

But these bodies, perhaps from their simple structure, appear to be adapted to attack all parts of the animal organization, and they are apt to affect the nervous system and circulation. In order to avoid these disadvantages, various attempts have been made to obtain bodies of a similar but more complicated structure, which should have a more specialized action, and would lower the temperature while leaving the nervous system and circulation unaffected. These attempts have been more or less successful, and we owe to them the introduction of three new remedies—kairin, thallin,

and antipyrin. The former two, after a brief period of trial, have been found more or less unsatisfactory; but the latter is perhaps, upon the whole, the best antipyretic that we possess, reducing the temperature and, at the same time, having few disadvantages. Salicylate of soda is nearly allied in chemical constitution to resorcin, and as a general antipyretic it is almost equal to antipyrin, and superior to it in cases of rheumatic fever. It is possible that we may still obtain antipyretics more powerful than any we yet possess, and specially adapted to the febrile conditions arising from different causes, for these antipyretics do not appear to be equally successful in different kinds of fever. Antipyrin is best in hectic fever, and salicylate of soda in rheumatic fever, but an antipyretic which will be thoroughly satisfactory in typhoid fever is still a desideratum.

I have said that antipyrin is generally free from any disagreeable action; but this is not always so, for it sometimes may produce collapse. This shows us that in the action of all our drugs we have two factors to consider, namely, the drug itself and the body into which we introduce it. We have just been considering the alterations in physiological action which may be produced by changes in the chemical constitution of our drugs; but there is another factor which is perhaps more difficult to investigate, and still more important in the treatment of disease, namely, the condition of our patients. The failure of our drugs to produce the effects we desire is one of the most trying occurrences in medical practice. Thus, in fever, we sometimes find that drugs will not reduce the pulse as they do in non-febrile conditions, and digitalis in pneumonia sometimes appears to have lost its sedative action on the heart altogether. Some years ago I thought that possibly this might be due to the high temperature producing paralysis of the nervous apparatus which restrains the heart, and supposed that the peripheral ends of the vagus in the heart might be paralyzed. I then made some experiments, which showed that I was wrong in this supposition. Several years afterward my friend Dr. Cash and I made some further experiments, which showed that the failure of digitalis to slow the heart in febrile conditions is really due to paralysis of the regulating nerves of the heart; but the part of them which is paralyzed by the heat is their roots in the medulla, and not their endings in the heart.

In other experiments which we made together, we found that the muscle of a frog poisoned by barium could be restored to its normal condition by a high temperature, and also by the application of potash salts. It occurred to us that, if we could saturate the body of an animal with potassium, we should be able to render it proof against the poisonous action of barium. On trying this, we succeeded in rendering animals so far resistant to the action of the poison that they were alive and well after animals of similar size, but unprotected, had succumbed to the action of the same dose of poison, although we did not succeed in ultimately saving the animals.

But Dr. Cash has pursued this line of investigation far beyond the limits of our mutual research, and he has obtained results which seem to me to be among the most extraordinary and the most promising in pharmacology. Knowing, as he did, that corrosive sublimate was an exceedingly powerful disinfectant, it occurred to him that it might be more harmful to disease germs than to the bodies of higher animals, and that he might be able, by the introduction of the poison into the body of an animal, to render it insusceptible to zymotic diseases. A similar idea had occurred to Koch, who injected corrosive sublimate into animals after previously inoculating them with anthrax; but his experiments failed, while Cash has proved successful by introducing the corrosive sublimate before inoculating with anthrax, and thus giving the drug the start of the disease. These experiments acquire an additional interest from the fact that M. Pasteur, although uncertain regarding the exact mode in which his process of inoculation for hydrophobia has brought about such satisfactory results, is disposed to think that the agent which prevents the disease is a chemical substance, and not a microbe.

When we look back for twenty years and see how far pharmacology has advanced since Crum Brown and Fraser's experiments directed it into a new path, we may hope that twenty years more may not only have greatly added to our stock of new remedies, but will have enabled us so to ascertain the condition of our patients that, either by the proper modification of a single remedy, by the proper admixture of remedies, or by proper changes in the food or surroundings of each patient, we may insure the action we desire, and we shall not have to feel, as we painfully do at the present, that our patients often die for lack of knowledge, not on our part, but on that of our art.

Nothing is more painful to a medical man than having to answer in the negative the agonized appeal, "Oh, doctor, can you do nothing?" of those who see passing away friends who are dearer to them than their own life. It is because we medical men know the value of human life and the extent of human suffering; because we are called upon to prolong the lives of those whom not only their friends but their country and the world at large can ill spare; because we must, if possible, relieve pain sometimes amounting to extreme torture in the sufferers themselves, and felt hardly less keenly by their friends, that we consider it is not only permissible, but is our imperative duty, to gain the knowledge we require to attain our object, even though we sacrifice the lives of animals and inflict upon them some pain—never wantonly, never carelessly, and almost always slight in comparison with what we often see our patients feel. Moreover, the lower animals suffer from disease as well as men, and we may hope that the advance of pharmacology will give us the means of relieving pain and prolonging life in them as well as in man.

IMPROVED ENSILAGE PRESS.

AT the late Royal Show at Norwich, a silver medal was awarded to the Aylesbury Dairy Company, of 31 St. Petersburg Place, Bayswater, for the mechanical arrangement used by Mr. C. G. Johnson in his ensilage stacking press. We will now describe that ingenious device in connection with Mr. Johnson's system.

Figs. 1 and 2 represent respectively a side view and a transverse section of a 100 ton stack before being thatched, and showing the construction of the stack bottom. Fig. 3 represents an ensilage stack at Mr. Johnson's farm, and which was awarded the Royal Agricultural Society's prize of £25 "for the best stack or other system for obtaining silage without a silo in England and Wales, in actual work during the winter of 1885-86."

The Aylesbury Dairy Company's stack, at their farm at Horsham, which received a certifica e of merit, was also pressed by Mr. Johnson's system. These were the only awards.

The judges in their award say: "The two stacks left for second inspection were built and pressed by the same system, which was invented by Mr. Johnson. The silage in both cases was excellent in quality." "We think the whole system excellent, and fraught with much value to the future of agriculture." "As the result of their inspection, the judges have come to the conclusion that the stack system of pressing green fodder has already been successfully carried out, and is capable of considerable extension on account of its great economy and the excellence of the results obtained."

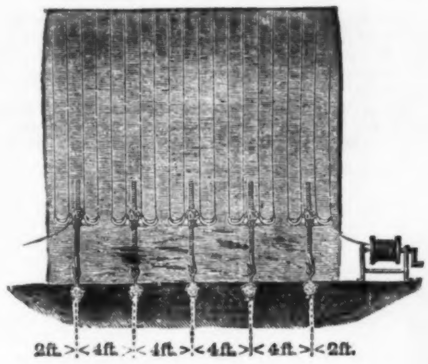


FIG. 1.

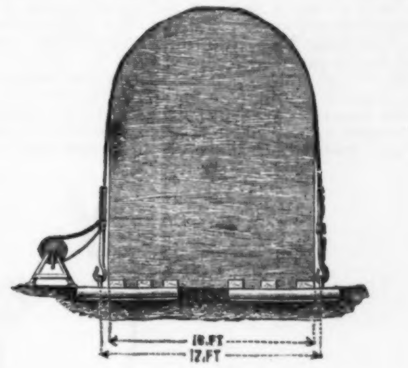


FIG. 2.

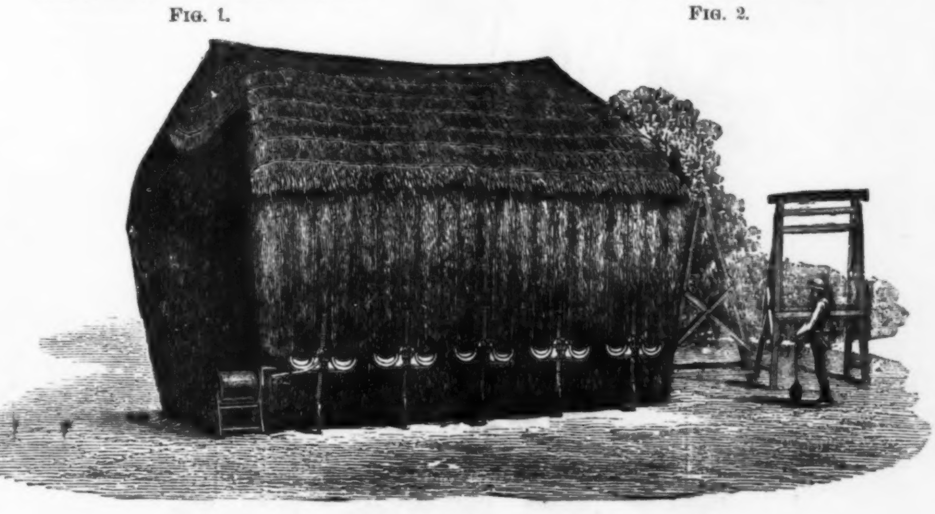


FIG. 3.

FIG. 4.

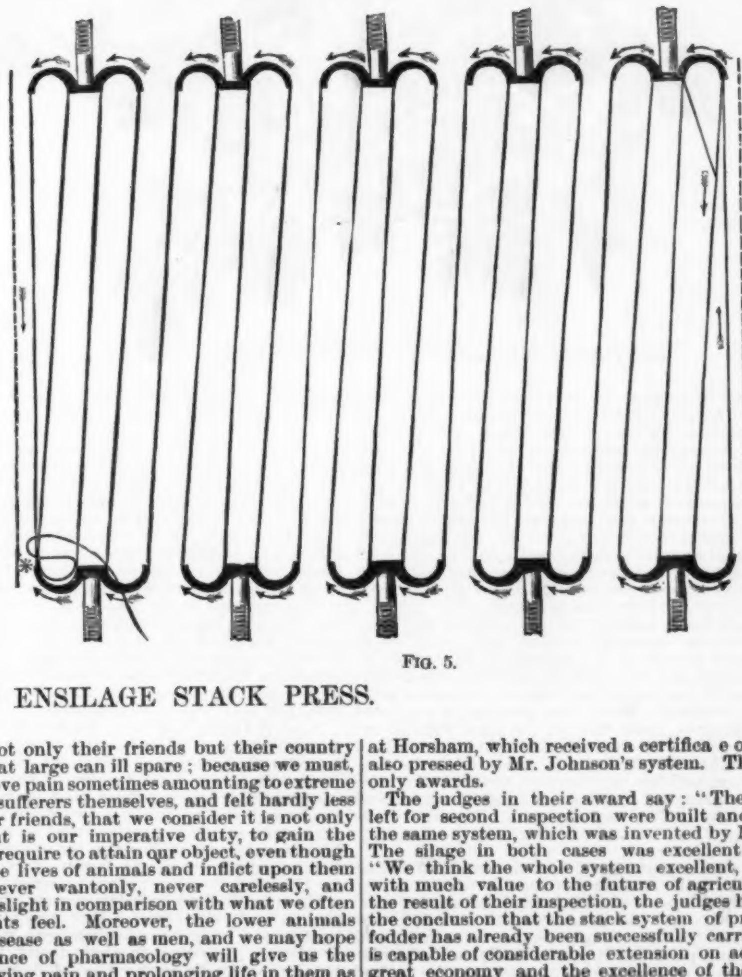


FIG. 5.

IMPROVED ENSILAGE STACK PRESS.

In Mr. Johnson's system a series of crossheads move loosely up and down on ratchet bars made fast to logs of wood, held down by the weight of the stack resting upon them. A flexible galvanized wire rope looped on to a crutch of the first crosshead at the end of the stack is then passed over the top of the stack and hitched on to a corresponding crutch at the other side, and, after being laced backward and forward over the whole series of crutches on all the crossheads in one continuous length of rope, thus forming a wire rope saddle over the stack, it is made fast by hitching it round the last crutch, the loose end being tucked under one of the tight laps, so that it is held fast as the pressure is put on. The crossheads are then tightened down by working a lever, which has pivoted on its ends a pawl which engages with the teeth of the ratchet bar, another pawl attached to the crosshead also engages with the teeth of the ratchet bar, and so holds good the crosshead in the position it has reached until the next stroke of the lever and pawl presses it down another tooth on the ratchet bar. The wire rope saddle is thus drawn down until the stack has been sufficiently pressed.

Fig. 4 is an illustration of the ratchet bar showing the hook and ring-bolt for attaching to the timber below the stack, the crosshead with the lever and pawl fulcrumed in position on the socket provided to receive it, and from which it can be lifted and carried from one crosshead to another, so that one lever and pawl are sufficient for any number of crossheads. Two are, however, provided for each of the larger sets of gear, so as to get through the work more quickly. The pin suspended by a piece of chain is for insertion in a hole in the ratchet bar, for the purpose of keeping the crosshead in position while the rope is being adjusted. The length of leverage is so adjusted that every stroke of the lever moves the crosshead down three-quarters of an inch, and a man pressing with the weight of 8 stones puts 3 tons on each crosshead, so that a stack 16 feet wide has a pressure of 200 lb. per square foot. This has been proved by dynamometer.

The friction being reduced to a minimum, the press works very freely, especially during the early part of the downward travel of the crosshead, when the resistance is slight and the work is easy, the full weight only coming on just when the stack is becoming sufficiently consolidated. When the pressure is removed for the stacking of more fodder, the wire rope is unhitched and wound on the reel, this being the work of a very few minutes. The waste is stated to be considerably decreased by this system, through the wire ropes closely gripping and compressing the sides and top of the stack. The reel shown at the side of the stack in Figs. 1 and 2 is not for obtaining pressure, but for taking up slack rope.

Fig. 5 of our engravings shows the mode of lacing the rope. At * the loose end of rope is tucked under one of the tight laps, so that it is held fast as the pressure is put on. All the gear being of iron, it is not easily injured by either rough usage or weather; and being light and portable, it can be easily carried under cover when not required for use, and may be looked upon as part of the ordinary equipment of a farmer's stock of implements, transferable from farm to farm.

Mr. Johnson, who we believe was one of the first (if not the first) to apply continuous pressure by mechanical means, does not now consider it necessary; but, if such pressure be preferred, all that is required with this gear is to attach the foot of the ratchet-bar direct to a large stone or block of concrete, or to reduce the weight of the block it may be attached to the end of a lever taken hold of by the ratchet bar. The action then is, that when the stack becomes sufficiently pressed to carry the weight, the stone or block of concrete will rise, and hang suspended, until the stack settles and lowers it to rest again. Mr. Johnson has abandoned the use of screws to draw down the crossheads, on account of their action being slow and the friction great. The new gear we have described is stated to thoroughly meet all difficulties.—*Iron.*

THE VALUE OF ENSILAGE.

WE regard it as valuable practical testimony in favor of having a large supply of ensilage on hand on the dairy or stock farm, as given in by J. C. Sibley, of the extensive breeding firm of Miller & Sibley, of Pennsylvania.

He says they have experimented with all manner of feed for cows, and have found that ensilage "overlays" them all; that as many cows can be wintered from the product of 25 acres of it, treated as ensilage, as from the product of 127 acres of meadow land treated in the usual way. He has found, also, that cattle do well on it during the entire year, and better than they do on the pasturage of the average farmer. He says: "I think 60 acres of land will keep 100 cows the year round." We suppose he means the forage part of the food of the cows, and we believe it would include 20 acres that might be devoted to clover and oats, rye or millet. Of course, it would have to be highly fertilized land, so as to raise enormous crops; but haply the 100 cows, fed on 60 acres, would soon give the land fertility, if the manure, liquid and solid, was all utilized. He says he can thus provide the food for a cow for one year at a cost of only $12. He also declares that this food will keep cattle in a healthier and more thrifty condition than any other forage; and for milch cows it is especially valuable, in that it increases both the quantity and quality of the milk.

Now, if this is half true, what is the use or sense in dairy or stock farmers being a lifetime in reaping the benefits that they may *commence* to rake in at once? It is just as easy for a farmer to find out how others succeed in practicing their kind of farming as it is to figure out the profits of a twine-binder for the great grain farmer. It is a system that makes the small farm big enough, and makes the large farm big enough to be divided among a large family of boys, or give scope for the head that can manage a large business, to have a big manufacturing enterprise on what is now called the ordinary sized farm. Men can make dairy goods, beef, run a breeding establishment, raise horses, hogs, or sheep, according to their tastes, the strong point being that food for any kind of domestic animals can thus be produced easily and cheaply, and at the same time keep adding fertility to the soil.—*U. S. Dairyman.*

THE CLAMMY COLUMBINE.

(AQUILEGIA VISCOSA.)

COLUMBINES may be found in most gardens, and where allowed to hybridize at will, the result is an effective mass of well varied and striking colors. They cross so freely that it is hardly possible to keep two kinds true to name if allowed to grow in close proximity; indeed, if grown in the same garden, the chances are that in the seedlings some alteration will have taken place. Where distinct kinds are desired, the better plan is to choose a few of the most marked, and grow them well apart; but if such as vulgaris, canadensis, chrysantha, and others of the robust kinds be cultivated, the progeny will be doubtful. Even if cærulea, a most distinct kind, grows along with chrysantha, the blue will be found to mix with the yellow, thus deteriorating the appearance of the flowers. In most soils columbines appear to be short-lived plants. A renewal, therefore, every two or three years will be found to be beneficial, as well as necessary. The plant here illustrated, along with which may be included A. alpina, pyrenacia, viridiflora, etc., belongs to a dwarf growing section, very useful for cultivation on low rockwork. It seldom grows more than one foot high, and its flowers, which are purple, are distinct from those of any other kind. The leaves are clammy and covered with long hairs. It flowers in May and June, and is a native of Southern Europe.—*K., The Garden.*

AQUILEGIA VISCOSA.—FLOWERS PURPLE.

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